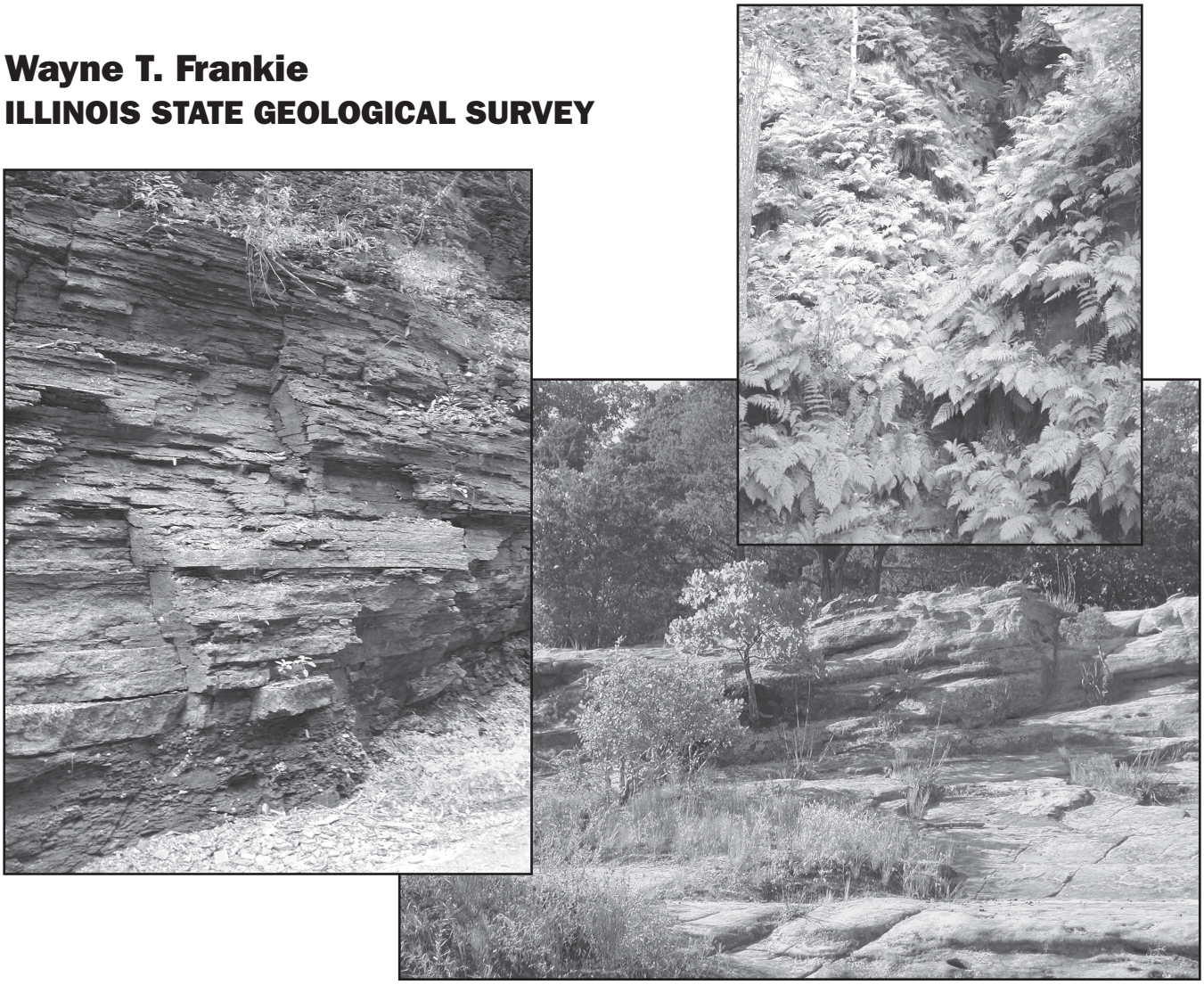
Guide to the Geology of Ferne Clyffe State Park and Surrounding Area, Johnson and Pope Counties, Illinois

Wayne T. Frankie
ILLINOIS STATE GEOLOGICAL SURVEY



Field Trip Guidebook 2004B **October 2, 2004**
October 23, 2004

ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

Cover photo: *From left to right; shale at Tunnel Hill, sandstone barrens at Round Bluff Nature Preserve, ferns at Ferne Clyffe State Park (photo by Wayne T. Frankie).*

Geological Science Field Trips The Illinois State Geological Survey (ISGS) conducts four tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students. Preregistration is required.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Geoscience Outreach Coordinator, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. Telephone: (217) 244-2427 or 333-4747. This information is on the ISGS home page: http://www.isgs.uiuc.edu.

Nine U.S. Geological Survey 7.5-minute Quadrangle maps (Bloomfield, Creal Springs, Eddyville, Glendale, Goreville, Lick Creek, Stonefort, Vienna, and Waltersburg) provide coverage for this field trip area.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

ISGS Illinois State Geological Survey

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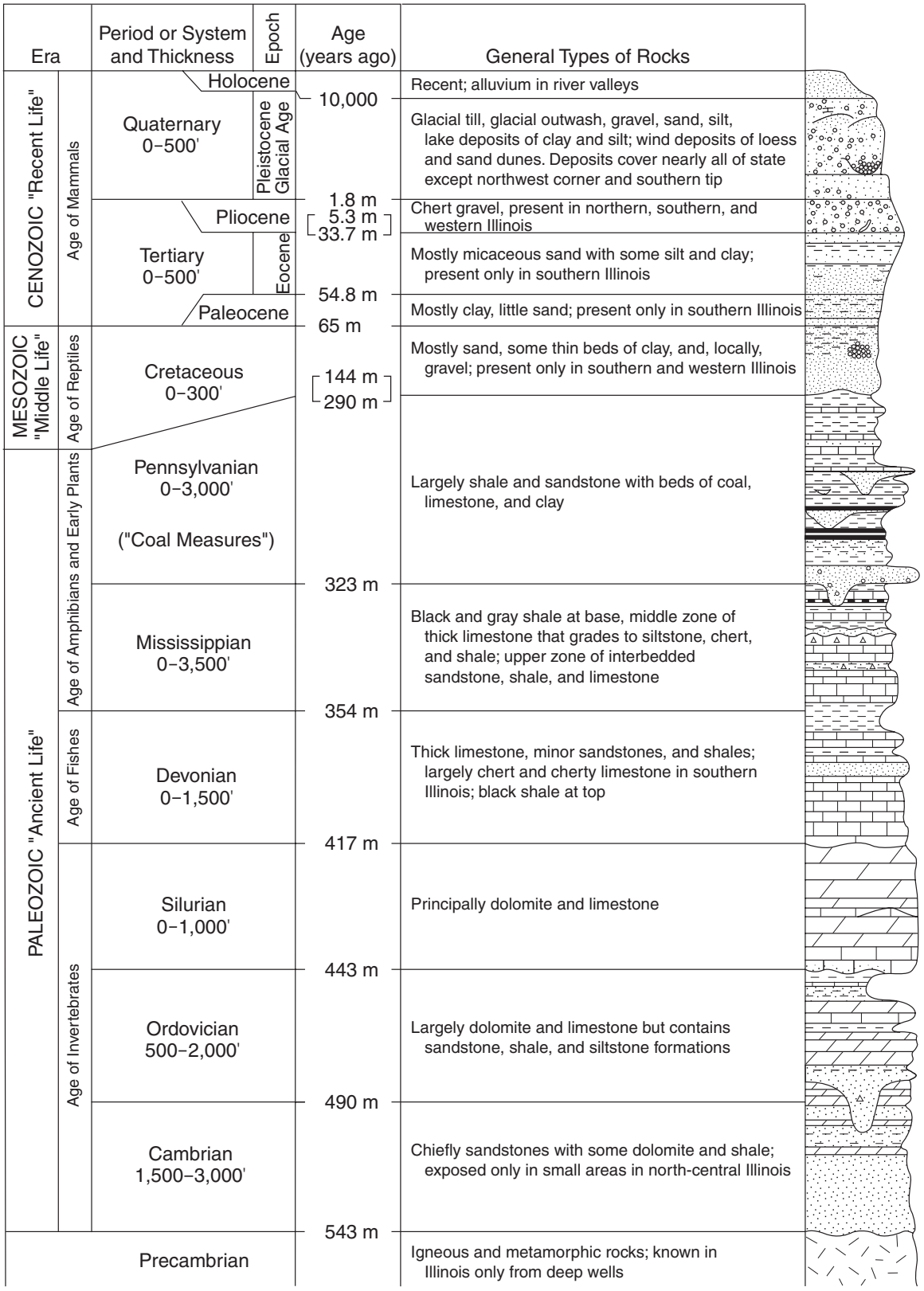


Generalized geologic column showing succession of rocks in Illinois.

INTRODUCTION

The Ferne Clyffe State Park field trip area, located in the driftless portion of southern Illinois, embraces one of the most scenic and geologically complex areas of the state. This geological science field trip will acquaint you with the *geology*[1], landscape, and mineral resources for part of Johnson and Pope Counties. Diverse topography, relief, structure, geological history, and distinct biota characterize the Ferne Clyffe field trip route, which traverses the scenic grandeur of the Shawnee Hills "Illinois Ozarks." Ferne Clyffe State Park is approximately 310 miles south-southwest of Chicago, 160 miles south-southeast of Springfield, and 37 miles north-northeast of Cairo. The northern boundary of the Shawnee Hills is approximately 3 miles north of Ferne Clyffe State Park.

GEOLOGIC FRAMEWORK

Precambrian Era

Through several billion years of geologic time, the area surrounding the Ferne Clyffe State Park area has undergone many changes (see the rock succession column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. These ancient rocks consist mostly of granitic and rhyolitic *igneous*, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. For about the next 4 million years, these Precambrian rocks were exposed at the surface. During this long period, the rocks were deeply weathered and eroded; the barren landscape they formed was probably quite similar to the topography of the present Missouri Ozarks.

Beginning about 500 million years ago, movement of crustal plates (plate tectonics) began to rip apart the Precambrian North American continent. In southernmost Illinois, near what is now the historic Kentucky–Illinois Fluorspar Mining District, rift valleys similar to those in east Africa formed. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

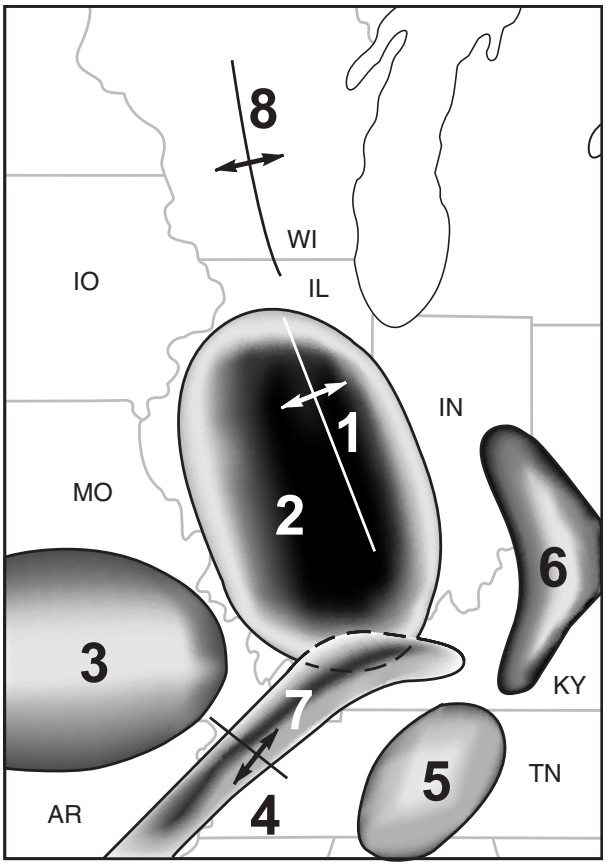


Figure 1 Location of some of the major structures in the Illinois region: (1) LaSalle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben–Reelfoot Rift, and (8) Wisconsin Arch.

Paleozoic Era

About 520 million years ago in the late Cambrian Period of the Paleozoic Era, the rifting stopped, and the hilly Precambrian landscape began to sink slowly on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the subsequent 290 million years, the area that is now called the Illinois Basin continued to accumulate sediments that were deposited in the shallow seas that repeatedly covered this subsiding basin. These inland seas connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was an embayment. During the Paleozoic and Mesozoic Eras, the Earth's thin crust was periodically flexed

[1] Terms in italics (except for Latin names) are defined in the glossary at the back of the guidebook. Also, please note: although all present localities have only recently appeared within the geologic time frame, the present names of places and geologic features are used because they provide clear reference points for describing the ancient landscape.

and warped in places as a result of tectonic forces associated with the collision of continental and oceanic plates and mountain building. Throughout the Paleozoic Era, these movements caused repeated invasions and withdrawals of the seas across the region. When the seas advanced, sediments were deposited, and when the seas withdrew, sediments were weathered and eroded. As a result, the sedimentary record shows some gaps.

The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a greater thickness of sediment to accumulate. By the end of the Paleozoic Era about 250 million years ago, the region continued to sink until at least 20,000 feet of sedimentary strata were deposited in the deepest part of the basin, located in the Rough Creek Graben area of southeastern Illinois and western Kentucky.

In the field trip area, *bedrock* strata range in age from more than 520 million years (the Cambrian *Period*) to less than 320 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all the *formations* were present.

The oldest exposed Paleozoic rocks in the field trip area are late Mississippian age (Chesterian) and occur in the southern part. These rocks represent a portion of the limestones, shales, and siltstones that formed from limey, muddy, and silty sediments deposited layer upon layer across ancient shallow seas that repeatedly covered the midcontinent from about 354 to 323 million years ago. The Mississippian age rocks are overlain by the Pennsylvanian age rocks.

The Pennsylvanian bedrock strata consist of sandstone, siltstone, shale, limestone, coal, and underclay that lie immediately beneath a thin cover of soil. The Pennsylvanian rocks were deposited as sediments in shallow seas and swamps between about 323 and 290 million years ago. Many of these Mississippian and Pennsylvanian age rocks are exposed in road and stream cuts, as well as along hillsides. The geologic map (fig. 3) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

Mesozoic Era

During the Mesozoic Era (290 to 65 million years ago), the rise of the Pascola Arch (fig. 1) in southeastern Missouri and western Tennessee produced a structural barrier that separated the Illinois Basin, for the first time, from other basins to the south. The embayment was closed and separated from the open sea to the south. Development of the Pascola Arch, in conjunction with the earlier sinking of the deeper portion of the basin north of the Pascola Arch in southern Illinois, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 4). The Ferne Clyffe field trip area is located along the southwestern rim of the Illinois Basin, in Johnson and Pope Counties.

Structural Features A number of *faults, synclines,* and *anticlines* occur within the field trip area. A fault is a fracture surface or zone in Earth materials along which there has been vertical and/or horizontal displacement or movement of the rock strata on both sides relative to one another. A syncline is an asymetrical fold in which the bedrock layers have been bent downward by compressive forces acting within the Earth's crust. The strata on both sides or limbs of a syncline dip (tilt) inward toward the axis or lowest part of the fold. Along the axis or central part of an eroded syncline the folded rocks are exposed. The opposite of a syncline is an anticline, in which the strata are bent upward into an arch.

A number of anticlines and synclines were formed during a major episode of folding and faulting that began at the end of the Pennsylvanian Period about 290 million years ago. This was a time when the Appalachian Mountains were forming along the eastern margin of North America. Another episode of faulting occurred later, during the Cretaceous Period, about 100 million years ago. Recurrent movements along faults in this region have occurred since then, and earthquakes within historic time indicate that movements are still taking place.

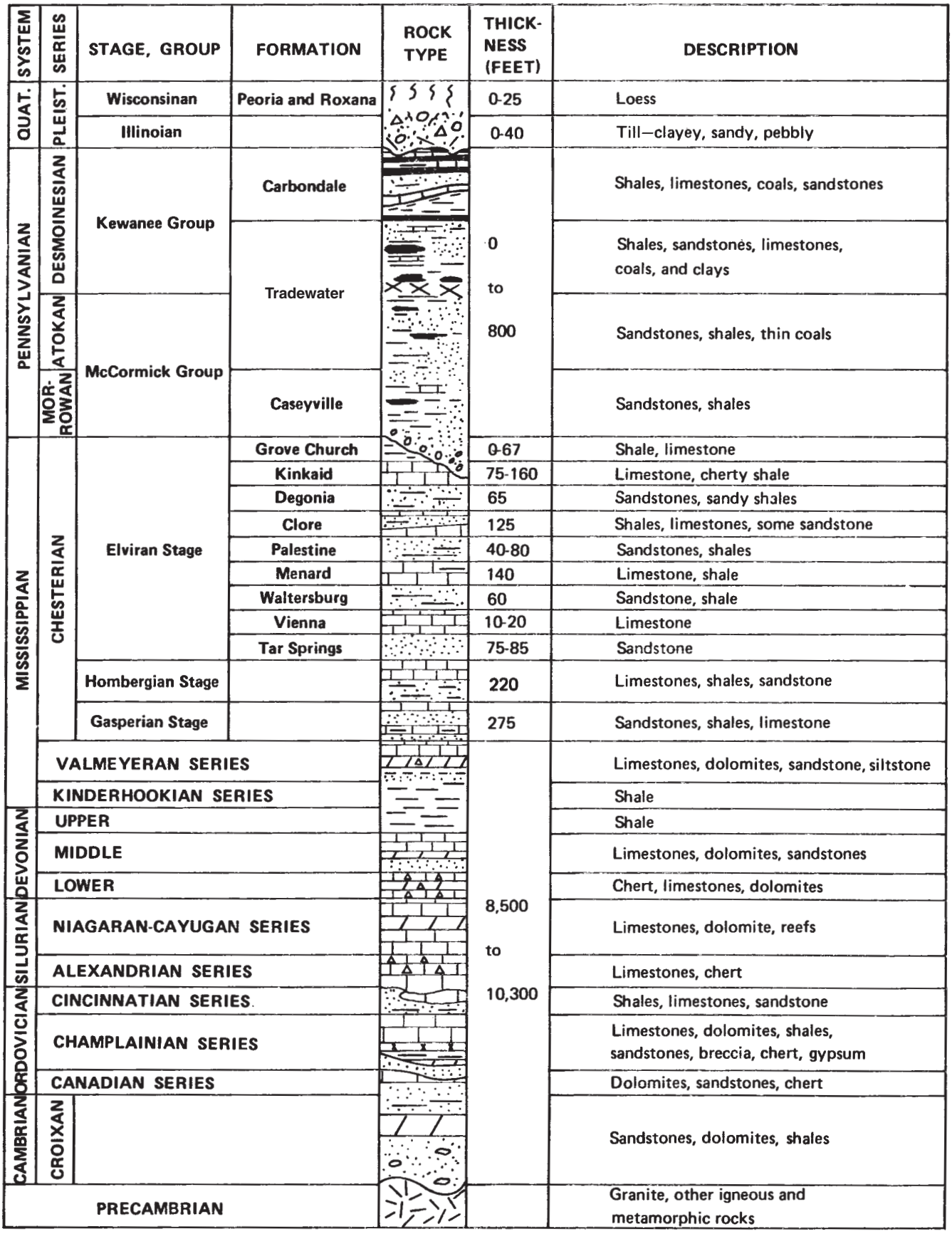


Figure 2 Generalized stratigraphic column.

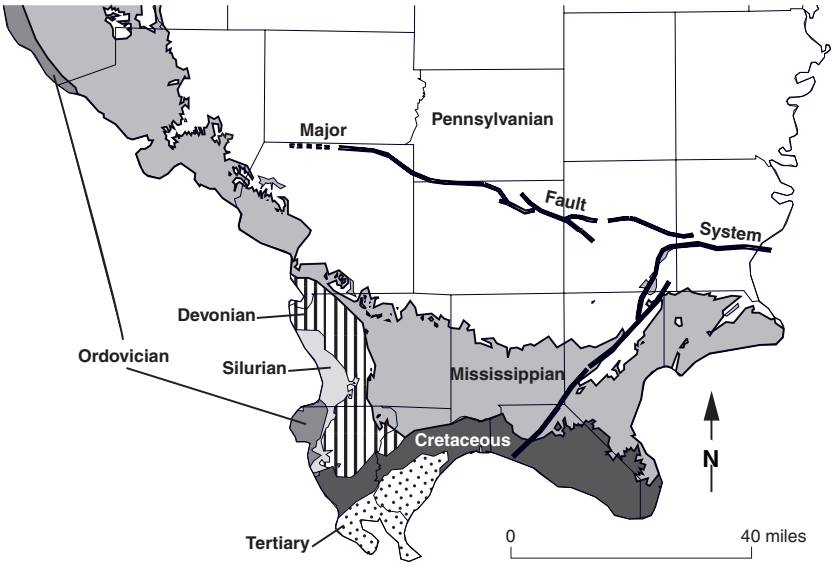


Figure 3 Bedrock geology in southern Illinois.

Strata exposed at the surface in the field tip area dip northeastward into the basin where they occur several hundred feet below ground. This simplified description of the regional structure is complicated by the folding and faulting that to some degree affect a large part of the Shawnee Hills.

Pennsylvanian Escarpment A prominent ridge, composed largely of sandstone strata that resist erosion, extends across the Shawnee Hills from the Mississippi River to the Ohio River. The steep south face of the ridge, known as the Pennsylvanian escarpment, is formed by the eroded, exposed edges of strata that dip gently northward toward the center of the Illinois Basin (fig. 4). This ramp-shaped land form is called a *cuesta,* which is characterized by a gentle slope on the "back" side of the ramp and a steeper face with exposed edges of bedrock layers on the other side. The crest of the escarpment in the field trip area is also the drainage divide between the Saline River system on the north and the Cache River and Bay Creek systems on the south. The Saline River and Bay Creek systems drain east and south into the Ohio River, and the Cache River system drains southwest to the Mississippi River. Although most of the escarpment is highly dissected by streams, some flat upland remnants are preserved along the crests of narrow ridges.

Streams cutting into the resistant Pennsylvanian escarpment have steep gradients (bottom slopes) and narrow, v-shaped valleys. South of the escarpment, the underlying Mississippian strata are more easily eroded, and little upland surface remains. This area is characterized by rounded hilltops and long hill slopes. Stream gradients are much lower than they are to the north, and the valleys are broader, having some flat areas along the bottom of large streams because of the deposition of sediments. The courses of the streams depend on the type and hardness of the bedrock through which they flow and on small structural features. This erosional surface has been in the process of development since the end of the Pennsylvanian Period nearly 290 million years ago and has been only slightly modified by the addition of a thin mantle of more recent surface deposits.

GLACIAL HISTORY

Cenozoic Era

Massive sheets of ice thousands of feet thick began to flow slowly southward from Canada about 1.8 million years ago during the Pleistocene *Epoch.* Approximately 300,000 years ago, the Illinois Episode of glaciation began. During its 175,000-year time span, the ice advanced three times out of the northeastern center of accumulation. Although ice sheets covered Illinois several times during the Pleistocene Epoch, North American continental glaciers reached their southernmost extent during the Illinois Glacial Episode around 270,000 year B.P. They advanced as far south as northern Johnson County, less than 3 miles north of the field trip area (fig. 5).

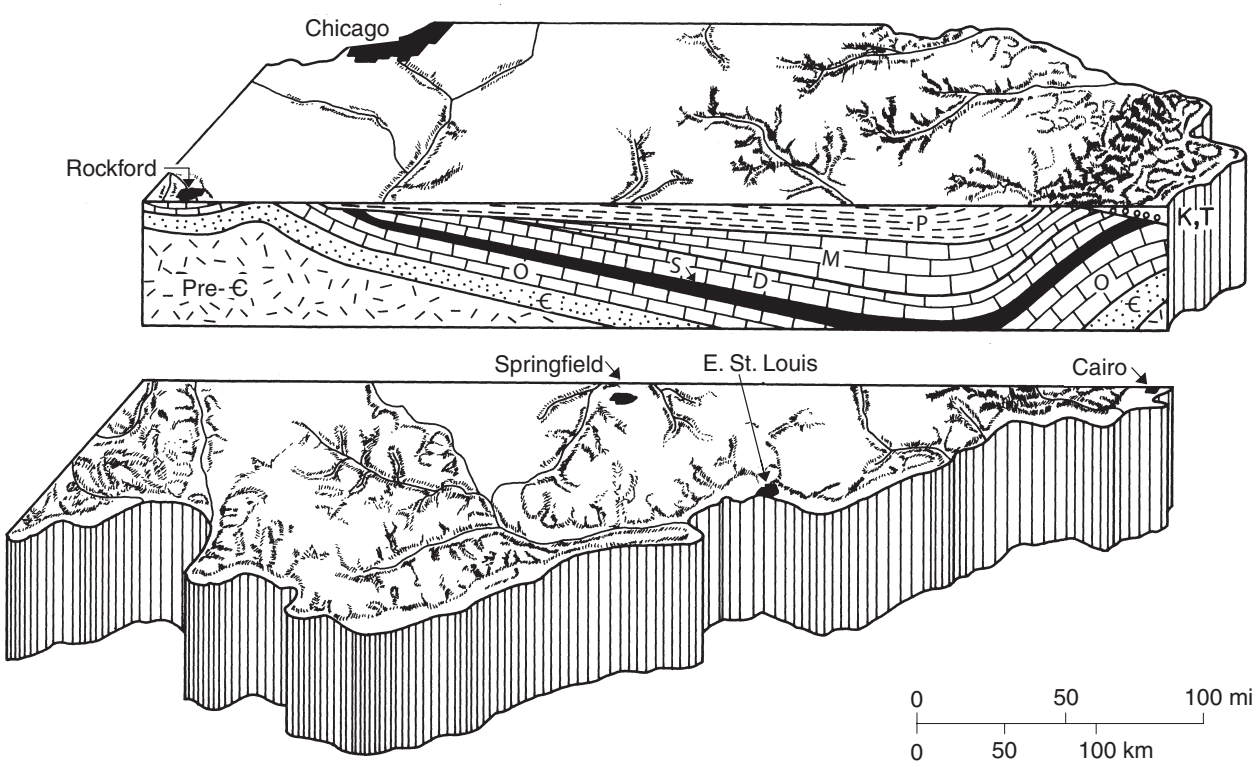


Figure 4 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated, and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

The glacier came within about 2 miles of the ridge crest of the gentle north slope of the Pennsylvanian escarpment.

Wisconsin Episode moraines were deposited in northeastern Illinois from approximately 25,000 to 13,500 years ago. Although Illinois Episode glaciers probably built morainic ridges similar to those of the later Wisconsin Episode glaciers in northeastern Illinois, the earlier moraines apparently were not so numerous and were exposed to weathering and erosion for approximately 280,000 years longer than their younger Wisconsin Episode counterparts. For these reasons, Illinois Episode glacial features generally are not as conspicuous as the younger Wisconsin Episode features. The absence of prominent morainal ridges across southern Illinois has two proposed explanations. The first is that the ice front apparently did not stand across the area long enough to deposit a distinct moraine, even though the ice may have been several hundred feet thick a few miles north of the glacial limit. Second, the absence of an end moraine may be an indication that the Illinois Glacial Episode ice sheet stagnated. Without forward movement of the glacier, little or no rock debris would have been carried to the ice margin to be deposited to form a moraine. Very thin drift in southern Illinois seems to indicate that the ice covered the region for a relatively short time.

Ice Front Lakes In front of the ice margin, melting ice from the Illinois Episode Glacier formed a number of lakes that extended southward from

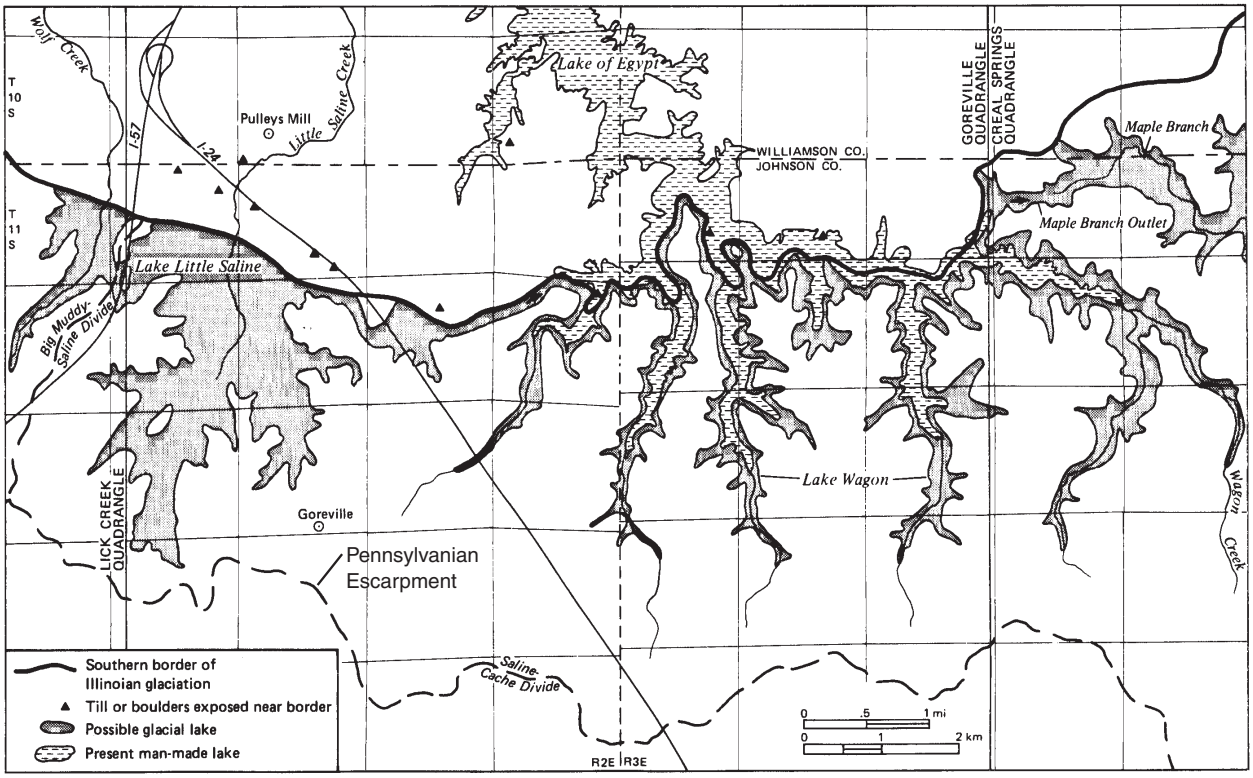


Figure 5 Glacial boundary and ice-front lakes in field trip area (modified from Willman and Frye 1980).

the ice margin into the valleys of north-flowing streams from the Pennsylvanian escarpment (fig. 5). The water level (surface elevations) varied from lake to lake. Just west of the field trip area, the water level in some of the western meltwater lakes became high enough in several places to briefly overflow southward through low sags in the Pennsylvanian escarpment. In the Ferne Clyffe area, water from the eastern meltwater lakes appeared to have drained eastward either across the front of the ice margin or beneath the ice via a series of subglacial channels into what is now the Saline River drainage system.

Throughout much of Illinois, the topography of the bedrock surface is largely hidden from view by glacial deposits except along major streams. In many areas, glacial drift is thick enough to mask the underlying bedrock surface completely. The field trip area was not covered either by glacial ice or by drift deposits. Therefore, the preglacial bedrock surface has been only slightly modified and subdued by a thin mantle of soil.

Although the field trip area was not glaciated, thick deposits of sand and gravel called valley trains were laid down along the Mississippi River during all of the glacial episodes, from the earliest pre-Illinois glacial episode (approximately 1.8 million years ago) to the Wisconsin Episode (which occurred approximately 25,000 to 13,500 years ago). During the severe winters, as meltwater streams diminished, the valley trains dried out. The harsh, bitter, northwest winds swirled across these deposits winnowing out and carrying the fine sand, silt, and clay eastward to deposit them across the upland. These windblown deposits called *loess* were laid down adjacent to the major rivers. The loess deposits are more than 50 feet thick along the Mississippi River; however, their thickness diminishes rapidly toward the east. Loess deposits in the field trip area range from about 13 feet on the west to less than 6 feet toward the northeast. Erosion has completely removed the loess in scattered areas within the uplifted Shawnee Hills area of the field trip. The loess deposits in this area form one of the parent materials from which the modern soils have developed.

GEOMORPHOLOGY

Physiography

Physiography is the study and classification of the surface features of the Earth based on a number of factors and conditions, including bedrock surface topography, extent of the various glaciations, differences in glacial topography, differences in age of the uppermost glacial drift, effects of erosion on the surface, similarities in geologic structure, and history of geologic changes. A physiographic province is a region in which the relief or landforms differ markedly from those in adjacent regions. The Ferne Clyffe field trip area is located in the central part of the western Shawnee Hills Section, the westernmost division of the Interior Low Plateaus Province (fig. 6). The Shawnee Hills Section has been called the "Illinois Ozarks" because of its rugged, scenic terrain.

The Shawnee Hills Section This section includes a complex dissected upland underlain by Mississippian and Pennsylvanian bedrock of varied rock types *(lithology)*. The section is located along the southern rim of the Illinois basin, with a cuesta (or escarpment) that forms a continuous ridge and drainage divide across southern Illinois from the Mississippi River eastward to the Ohio River. Local structure and varied lithology of the bedrock have influenced the courses of a number of streams here. Solution features *(karst)*, such as sinkholes and the absence of surface streams, are reflected in the local topography, where the underlying bedrock is the Mississippian Menard and St. Louis Limestones.

NATURAL DIVISIONS AND GEOLOGY

Glacial history has played an important role in shaping Illinois topography by eroding the preglacial landscape and depositing glacial sediments. The type of bedrock (sandstone, limestone, or shale) and the topography influence the diversity of plants and animals (biota) of Illinois by strongly influencing the diversity of habitats. Geologic processes form, shape, and create the topography on all of the Earth's surface. Specifically, geological processes not only determine the composition of the parent material of soils, but also form soils through the weathering of parent materials. Thus, the geology of a region is the foundation of its habitats.

Natural Divisions

The state has 14 different Natural Divisions. These divisions are distinguished according to differences in significant aspects of topography, glacial history, bedrock geology, soils, aquatic habitats, and distribution of plants and animals (flora and fauna). A strong relationship exists between the Physiographic Divisions of Illinois and the Natural Divisions of Illinois because the geologic factors used to determine the Physiographic Divisions were important elements used to define the boundaries of the Natural Divisions. Of the 14 Natural Divisions in Illinois, the field trip area is located in the Shawnee Hills Division. The geographic area of the Shawnee Hills Division is equivalent to the Shawnee Hills Section. The following descriptions of the Natural Divisions are modified from descriptions by Schwegman (1973).

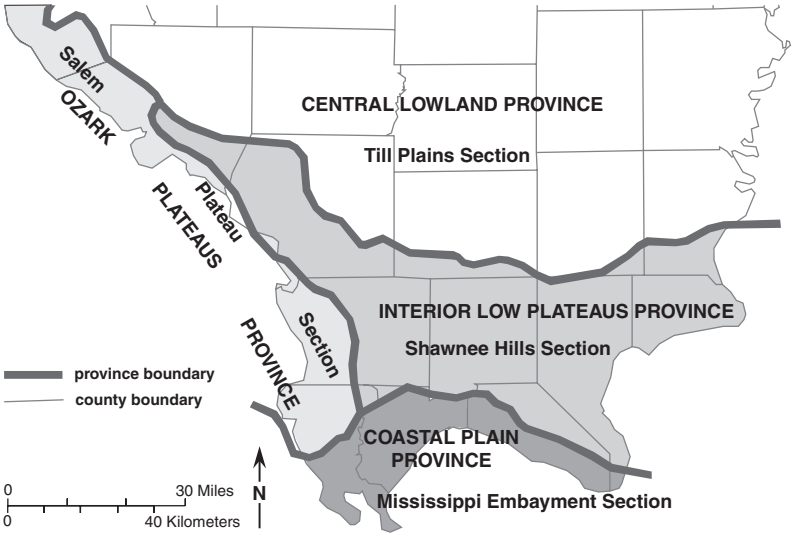


Figure 6 Physiographic divisions of Illinois (modified from Leighton et al. 1948).

The Shawnee Hills Division Extending across the southern tip of the state from Fountain Bluff on the Mississippi River to the Shawneetown Hills near the mouth of the Wabash River, this unglaciated hill country is characterized by a high east-west escarpment of sandstone cliffs forming the Greater Shawnee Hills and a series of lower hills underlain by limestone and sandstone known as the Lesser Shawnee Hills. Originally this division was mostly forested, and considerable forest remains to the present time. A number of distinctive plant species are restricted to this division of Illinois.

Bedrock The Greater Shawnee Hills form a band along the northern edge of the division that consists of massive Pennsylvanian sandstone strata that dip northward toward the Illinois Basin. The range of hills averages 10 miles wide and borders the Lesser Shawnee Hills to the south. The Lesser Shawnee Hills are underlain by Mississippian limestone and sandstone; sinkholes and caves are locally common features.

Topography The topography of the Shawnee Hills Division is very rugged with many bluffs and ravines. The north slopes of the Greater Shawnee Hills Section are relatively gentle; however, the south slopes consist of many escarpments, cliffs, and overhanging bluffs. Streams have eroded canyons in the sandstone. The Lesser Shawnee Hills average about 200 feet lower than the Greater Shawnee Hills. The Lesser Shawnee Hills have local areas of sinkhole topography.

Soils The soils are derived mainly from loess. Narrow bands of moderately developed deep loess soils occur along the Mississippi River in Jackson County and along the Ohio River in eastern Hardin County; most of the soils, however, are derived from thinner loess and are strongly developed. Claypan and fragipan layers are frequent.

GUIDE TO THE ROUTE

We will start the trip at the Round Bluff Nature Preserve Lakeside Shelter in Ferne Clyffe State Park (NE, NW, SW, Sec. 27, T11S, R2E, 3rd P.M.., Goreville 7.5-minute Quadrangle, Johnson County). The first three stops and lunch are within Ferne Clyffe State Park. See directions below for location of stops within the park. Following lunch, the mileage will start at the entrance/exit of Ferne Clyffe State Park.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an Illinois State Geological Survey (ISGS) vehicle with flashing lights and flags, please obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Private property Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests, and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, follow these simple rules of courtesy:

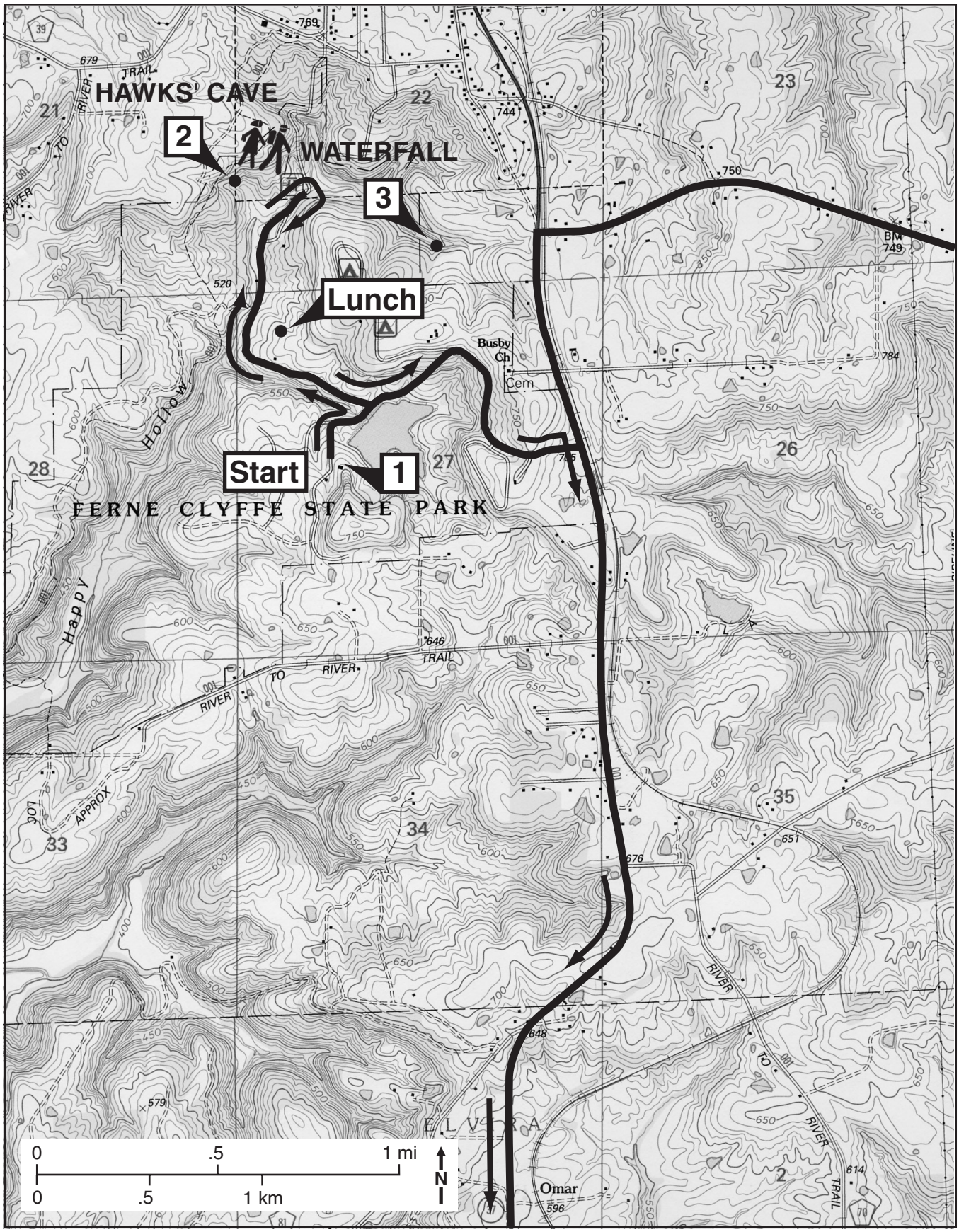
- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat public property as if you were the owner—which you are!
- Stay off all mining equipment.
- Parents must closely supervise their children at all times.

When using this booklet for another field trip with your students, a youth group, or family, remember that you must get permission from property owners or their agents before entering private property. No trespassing please.

Nine USGS 7.5-Minute Quadrangle maps (Bloomfield, Creal Springs, Eddyville, Glendale, Goreville, Lick Creek, Stonefort, Vienna, and Waltersburg) provide coverage for this field trip area.

Stop 1: Round Bluff Nature Preserve, Ferne Clyffe State Park (NE, SW, Sec. 27, T11S, R2E, 3rd P.M., Goreville 7.5-minute Quadrangle, Johnson County).

Miles to next point	Miles from start	
0.0	0.0	Exit the Lakeside Picnic Shelter parking lot, and head toward the main park road.
0.1	0.1	T-intersection. Turn right onto the main park road, and head toward the lake.
0.1	0.2	Y-intersection. TURN LEFT. Follow signs indicating picnic areas and shelters. Pass by Shady Bend Picnic Shelter on the right, Bluff View Picnic Area on the right, and Bluff Creek Picnic Area on the left.
0.7	0.9	Entrance to Hillside Picnic Shelter is on the right. Turn right and park in the large parking lot.


HAWKS' CAVE
2
WATERFALL
3
Lunch
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1
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APPROX
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N

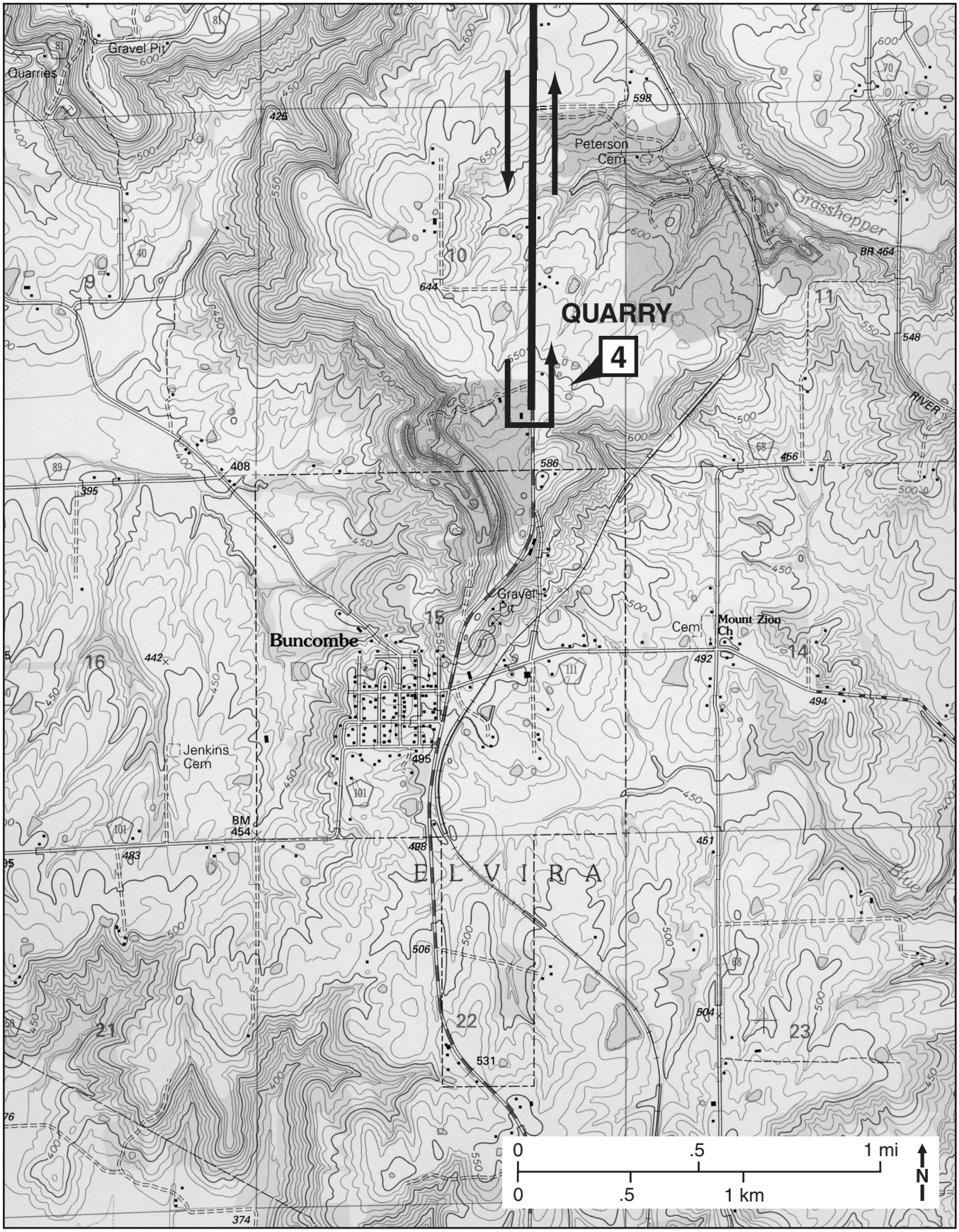
STOPS 2, 3, and LUNCH: Hill Side Picnic Shelter, Ferne Clyffe State Park (SW, SW, SW, Sec. 22, T11S, R2E, 3rd P.M., Goreville 7.5-minute Quadrangle, Johnson County).We will hike to Stops 2 and 3 from the parking lot, and return for lunch.

STOP 2: Hawks' Cave, Ferne Clyffe State Park (SW, NE, SW, Sec. 21), is located along Hawks' Trail.

STOP 3: Waterfall, Ferne Clyffe State Park (SW, SW, SE, Sec. 22), is located along Big Rocky Hollow Trail. Both of the trail heads are located to the north at the end of the road. See map of Ferne Clyffe State Park.

LUNCH: Hill Side Picnic Shelter, Ferne Clyffe State Park.

0.0	0.9	Exit parking lot and follow main park road back to the entrance. Reset your odometer to 0.0 at the park entrance.
0.0	0.0	Set your odometers to 0.0 at the entrance/exit of Ferne Clyffe State Park. Exit Ferne Clyffe State Park. Turn right onto Illinois Route 37.
0.5	0.5	T-intersection from the right (Rebbman Lane). CONTINUE AHEAD.
0.2	0.7	Historical marker on the right. This marker commemorates the July 1, 1778, campsite for Lt. Col. Clark's troop of 170 volunteers. At the time, the site had a nearby spring and was north of a place called Buffalo Gap. The men were marching from Fort Massac to capture the British post at Kaskaskia. This attack and a later one at Vincennes, Indiana, prevented the British and their Indian allies from invading Kentucky. It also secured the Illinois Territory for the United States during the Revolutionary War.
0.2	0.9	T-intersection from the right (Buffalo Gap Lane). CONTINUE AHEAD.
0.3	1.2	T-intersection from the left (Tall Tree Lake Road). CONTINUE AHEAD.
0.6	1.8	T-intersection from the right (Michaels Road). CONTINUE AHEAD.
0.9	2.7	T-intersection from the left. Entrance to Southern Illinois Stone Company, Buncombe Quarry. TURN LEFT.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BR 464
RIVER
Buncombe
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Jenkins Cem
BM 454
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STOP 4: Southern Illinois Stone Company, Buncombe Quarry (NW, Sec.11, T12S, R2E, 3rd P.M., Vienna 7.5-minute Quadrangle, Johnson County).

0.0	2.7	Retrace the route back to the entrance of quarry. Turn right onto Illinois Route 37.
2.7	5.4	Entrance to Ferne Clyffe State Park on the left. CONTINUE AHEAD.
0.25	5.65	T-intersection from the right (Gore Canyon Road). CONTINUE AHEAD.
0.4	6.05	T-intersection from the right (Tunnel Hill Road). TURN RIGHT. After making the turn, pass under the Union Pacific and Burlington Northern railroad overpass. Tunnel Hill Road traverses along the crest of a major drainage divide. The Pennsylvanian Escarpment forms this drainage divide. Rain falling on the right side of the road flows south and west toward the Cache River, and rain falling on the left side of the road flows north and east toward the Saline River. The Cache River empties into the Mississippi River, and the Saline River empties into the Ohio River. Located along Tunnel Hill Road are a number of small ponds. These ponds are man-made and do not represent karst topography. Close examination of the shape of the ponds on a topographic map show a straight edge on most of the ponds that usually is perpendicular to the downhill slope of the land. This straight feature represents an earthen dam. In a karst region, the ponds are generally elliptical in shape.
1.0	7.05	T-intersection from the right (Gore Canyon Loop Road). CONTINUE AHEAD.
0.45	7.5	T-intersection from the left (Deer Ridge Road). CONTINUE AHEAD.
0.65	8.15	T-intersection from the left (Bensen Loop). CONTINUE AHEAD.
0.25	8.4	Crossroad intersection (Bensen Loop from the left, and Chapman Lane from the right). CONTINUE AHEAD.
0.15	8.55	Eastbound entrance ramp for Interstate 24 on the right. CONTINUE AHEAD.
0.1	8.65	Cross over Interstate 24.
0.1	8.75	Westbound entrance ramp for Interstate 24 on the left. CONTINUE AHEAD.
0.15	8.9	T-intersection from the left (Parish Ridge Road, dead end). CONTINUE AHEAD.
0.7	9.6	T-intersection from the right (Dutchman Lake Road). CONTINUE AHEAD.
0.3	9.9	Great view of the Pennsylvanian Escarpment to the right.
0.1	10.0	T-intersection from the left (Webbtown Road). CONTINUE AHEAD.

0.7	10.7	T-intersection from the right (Webb Lane, dead end). CONTINUE AHEAD.
1.0	11.7	T-intersection from the left (Larkins Creek Road). CONTINUE AHEAD.
0.25	11.95	Crossroad intersection (Bowmans Bottom Road from the right, and Vinson Lane from the left). CONTINUE AHEAD.
0.25	12.2	Tunnel Hill Road curves 90 degrees to the right, followed by six additional 90-degree curves alternating left and right. The road is following along the crest of the drainage divide.
1.0	13.2	T-intersection from the left (Whitburg Lane). CONTINUE AHEAD.
0.8	14.0	T-intersection from the left (Creal Springs Road). CONTINUE AHEAD. Creal Springs is approximately 6.5 miles to the left. The mineral springs at Creal Springs were discovered in 1880.
0.15	14.15	T-intersection from the left (Culterville Lane). CONTINUE AHEAD. Enter Tunnel Hill.
0.1	14.25	T-intersection from the left (Colfax Lane). CONTINUE AHEAD. The rails to trails Tunnel Hill bike trail is on the left.
0.05	14.3	T-intersection from the left (Main Street). TURN LEFT. Small parking lot on the right. On the day of the field trip turn left and park along the overflow parking lot east of the bike trail.

STOP 5: Tunnel Hill (SE, SE, NE, Sec. 35, T11S, R3E, 3rd P.M., Creal Springs 7.5-minute Quadrangle, Johnson County).

0.0	14.3	Exit parking lot and head toward Colfax Lane. Cross the bike trail and turn left onto Tunnel Hill Road.
0.4	14.7	Road begins 45-degree curve to the left. T-intersection from the left (Jackson Road). CONTINUE AHEAD. The tunnel is located directly beneath the intersection with the road to the left.
0.65	15.35	TWO-WAY STOP. Intersection of US Route 45 and Tunnel Hill Road. TURN LEFT onto US Route 45. Tunnel Hill School is on the right, just before the intersection.
0.9	16.25	T-intersection from the left (Jackson Road). CONTINUE AHEAD.
1.5	17.75	T-intersection from the left (Harpertown Road). CONTINUE AHEAD.
0.1	17.85	Historical marker on the left: “Old Ft. Massac and Kaskaskia Trail crossed this county at this point.”


N E L H I L L
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S N F
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Tunnel Hill
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Albright
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0.5	18.35	T-intersection from the right (Reynoldsburg Road). CONTINUE AHEAD.
0.7	19.05	T-intersection from the right (Gum Springs Road). CONTINUE AHEAD.
0.25	19.3	T-intersection from the right (Ozark Road/1700N). TURN RIGHT.
0.05	19.35	T-intersection from the left (Red Cedar Lane). CONTINUE AHEAD.
0.5	19.85	T-intersection from the right (Ondessonk Road). CONTINUE AHEAD. Camp Ondessonk, a Christian youth camp, is to the right.
0.25	20.1	T-intersection from the left (Darnell Road). CONTINUE AHEAD.
0.7	20.8	T-intersection from the right (Kennedy Lane). CONTINUE AHEAD.
0.4	21.2	Road curves 90 degrees to the right. Y-intersection at the curve. Smith Lane is on the left. CONTINUE AHEAD on Ozark Road.
0.15	21.35	Rushing Cemetery on the right.
0.3	21.65	Road curves 90 degrees to the left. Y-intersection at the curve; Backentuck Road on the right. CONTINUE AHEAD on Ozark Road.
1.0	22.65	T-intersection from the left (Belville Road). CONTINUE AHEAD.
0.65	23.3	Enter Pope County. Road changes from blacktop road to a gravel road.
0.45	23.75	Zion Church and Zion Cemetery is on the left. Old Zion Cemetery is on the right.
0.1	23.85	Main road curves to the left, BEAR LEFT. T-intersection from the right (Trigg Tower Road). One-way stop from the right. Ozark Road becomes McCormick Road at the curve. The old Trigg "fire watch" Tower is 4.5 miles to the right. Teal Pond is 5 miles to the left, and Bell Smith Springs is 7 miles to the left.
0.15	24.0	Power line crosses over road. Hidden from view is a railroad tunnel located approximately 130 feet below ground directly beneath the road. The Illinois Central Railroad tunnel trends parallel with the position of the power lines. At slightly more than 1.3 miles (7,000+ feet), this is the longest railroad tunnel in Illinois. The road we are traveling trends to the northeast. The route traverses the divide between the Saline River drainage system to the left (north and northeast) and the Bay Creek drainage system to the right (south and southeast). The drainage divide is largely controlled by the McCormick Anticline, a northeast-southwest–trending bedrock structure. The Bay Creek Syncline lies about 1.75 miles to the south and southeast, roughly paralleling the McCormick Anticline.
0.05	24.05	T-intersection from the right (Glen St. Falls Road). CONTINUE AHEAD. Jackson Falls is located 1.8 miles to the right.

0.3	24.35	Old abandoned Zion Church is on the right. A number of old drag lines are on the left.
1.1	25.45	Road curves 90 degrees to the right. T-intersection from the left (Bynum Road). CONTINUE AHEAD. Olive Baptist Church, established in 1855, is on the left, just past the curve. Teal Pond is 3 miles, Bell Smith Springs is 5 miles, and Burden Falls is 2 miles to the right.
0.6	26.05	Y-intersection. BEAR RIGHT. Pope County Road 24 is to the left, which leads to Old town 4 miles to the north. Road changes from blacktop to a gravel road just past the Y-intersection.
0.4	26.45	Enter Burden Falls Wilderness Area. The road is designated as National Forest Road 402.

Burden Falls Wilderness is located adjacent to Bay Creek Wilderness and is a stone's throw away from Bell Smith Springs Recreation Area. Burden Falls Wilderness is a central hardwood ecosytem with some pine plantations. Trails for hiking and equestrian use take you by some indications of past use by people including a homestead, fruit trees, cemeteries, and abandoned roads. There is a small, very scenic waterfall located on the southern edge of the wilderness.

Burden Falls Wilderness was designated as a wilderness area by the Illinois Wilderness Act of 1990 (PL101-633); 3,723 acres of the 3,775 total acres are National Forest System Land.

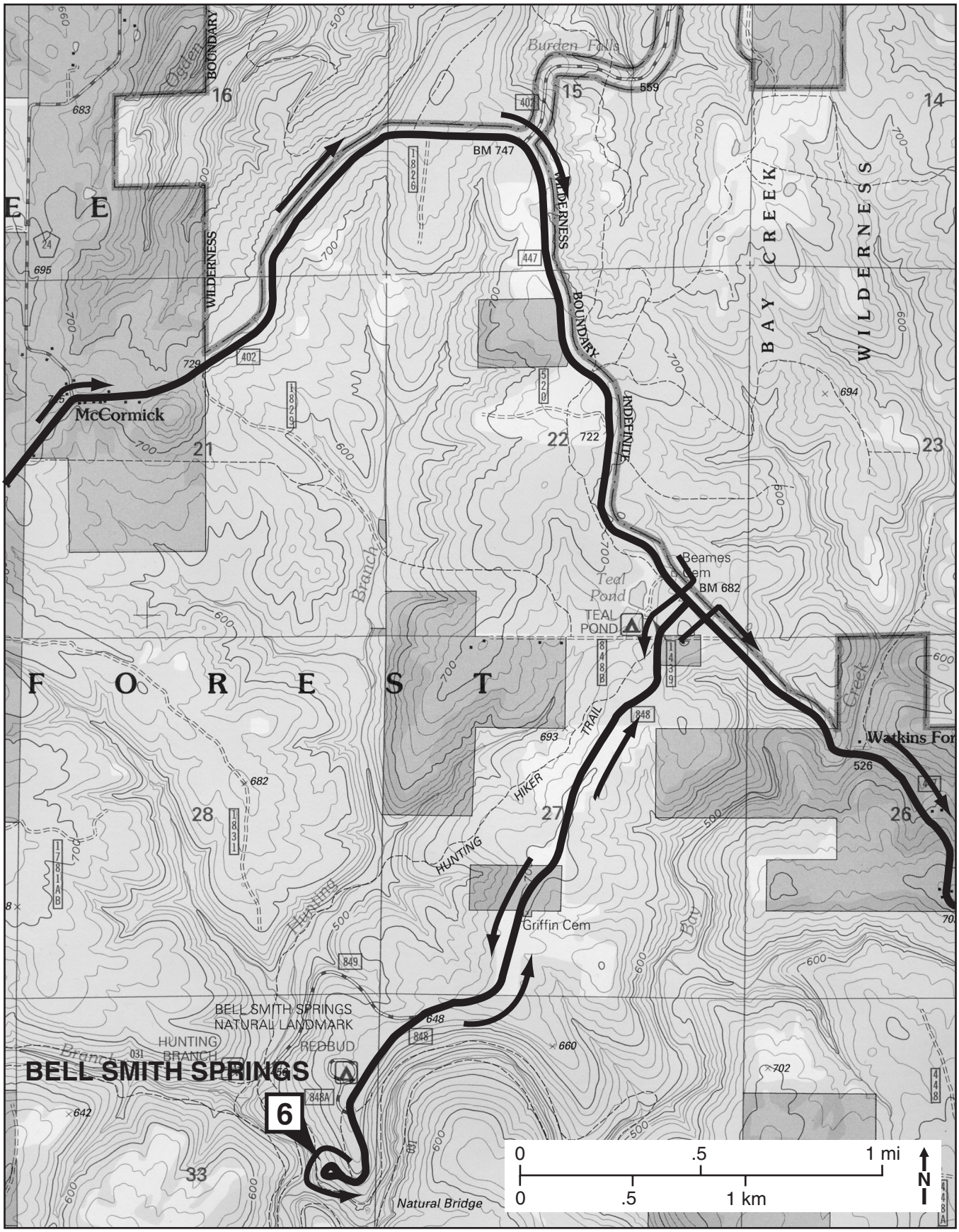
Parking is limited along Forest Road 402. Stonefort topographic map is recommended.

WARNING! All wilderness users should exercise good outdoor ethics, which include bringing a compass, appropriate maps, drinking water, and "leave no trace" practices.

1.65	28.1	Y-intersection. BEAR RIGHT onto National Forest Road 447. National Forest Road 402 continues to the left. Burden Falls is 0.5 miles to the left. State Highway 145 is 4 miles to the left, and Bell Smith Springs is 3 miles to the right. We will not visit Burden Falls on the day of scheduled field trip, but the following information is included for your reference on future trips.

Burden Falls is reached from the small parking lot at Burden Falls. Follow the trail along the east side of Burden Creek to reach the falls. Note that there is "smaller" upper and a "larger" lower set of falls.

Burden Falls, like Ferne Clyffe, is composed of the Caseyville Formation. Look for primary sedimentary structures such as cross-bedding and ripple marks. Is the Caseyville from Burden Falls different than that from Ferne Clyffe? Does the lithology differ? Is the Pennsylvanian environment the same at Burden Falls as it was at Ferne Clyffe?


BOUNDARY
Ogden
16
683
Burden Falls
15
559
14
BM 747
WILDERNESS
BOUNDARY
BAY CREEK WILDERNESS
WILDERNESS
695
700
729
McCormick
402
447
694
21
22
722
INDEFINITE
23
Beames Cem
BM 682
Teal Pond
TEAL POND
F O R E S T
Branch
693
TRAIL
HIKER
HUNTING
682
28
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Watkins For
Griffin Cem
Bay
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BELL SMITH SPRINGS
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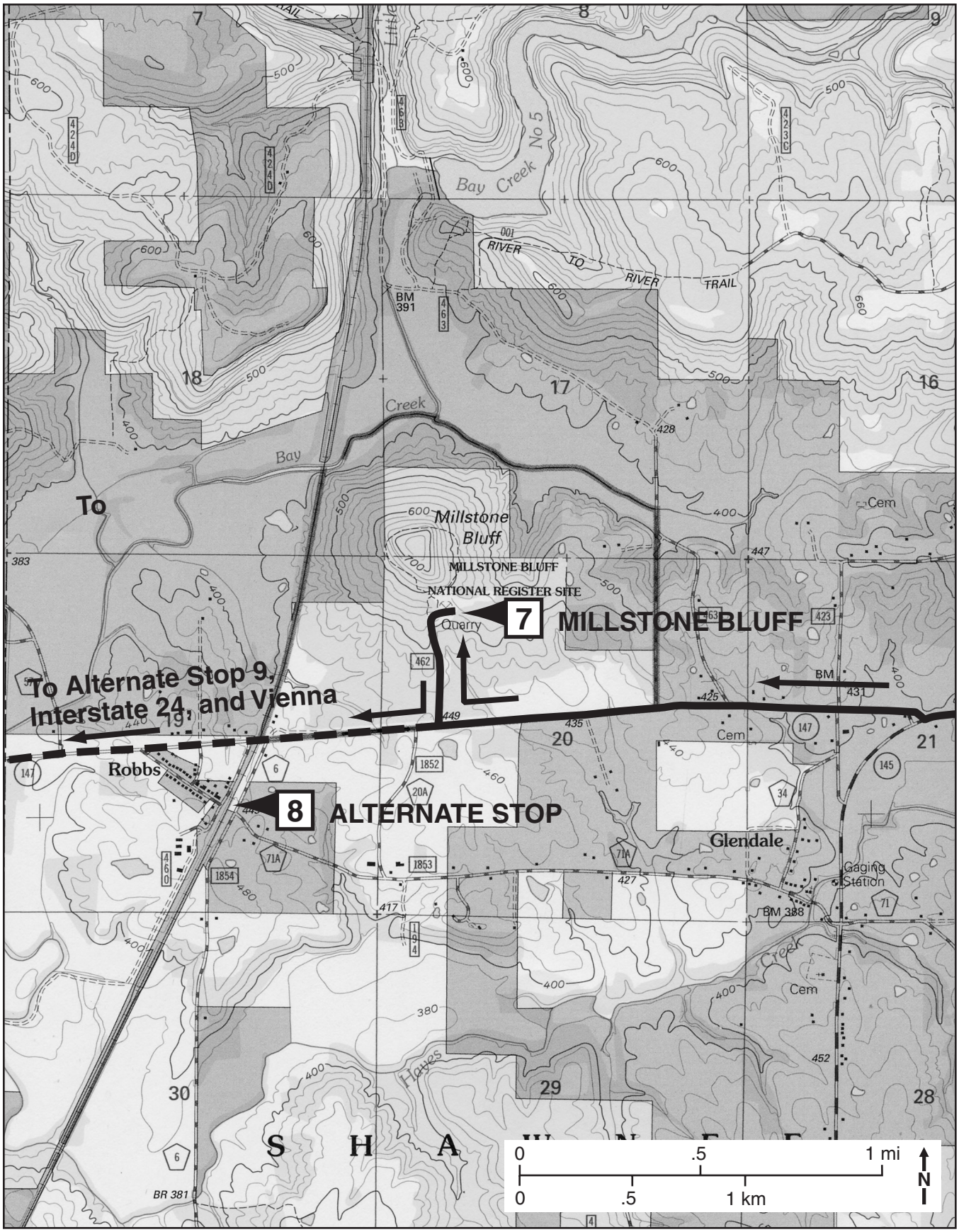
0.6	28.7	Sign for Bay Creek Wilderness Area on the left.
		Bay Creek Wilderness is located adjacent to Burden Falls Wilderness and is close to Bell Smith Springs Recreation Area. Bay Creek Wilderness is a central hardwood ecosystem with some pine plantations. Contained in the wilderness is the Bay Creek Wild and Scenic River Study Corridor. Trails for hiking and equestrian use take you by some indications of past use by people including homesteads, fruit trees, cemeteries, and abandoned roads.
		Bay Creek Wilderness was designated as a wilderness area by the Illinois Wilderness Act of 1990 (PL101-633). There are a total of 2,866 acres.
		Several small parking areas and trail heads are adjacent to Forest Road 447. Stonefort topographic map is recommended.
0.8	29.5	Entrance to Teal Pond campground on the right. CONTINUE AHEAD.
0.1	29.6	T-intersection from the right (National Forest Road 848). TURN RIGHT, heading toward Bell Smith Springs.
1.45	31.05	T-intersection from the right (National Forest Road 849). CONTINUE AHEAD. Hunting Branch is to the right.
0.35	31.4	T-intersection from the right (National Forest Road 848A). CONTINUE AHEAD. Red Bud Camp Ground is to the right.
0.2	31.6	Bell Smith Springs upper parking lot on the left. CONTINUE AHEAD. Enter lower parking lot and follow the loop road back to the upper parking lot.
0.2	31.8	Bell Smith Springs upper parking lot on the right. Pull over and park. On the day of the field trip, we will use both the upper and lower parking lots.

STOP 6: Bell Smith Springs (SE, NW, NE, Sec. 33, T11S, R5E, 3rd P.M., Stonefort 7.5-minute Quadrangle, Pope County).

0.0	31.8	Leave Bell Smith Springs area. Retrace the route on National Forest Road 848 to the T-intersection with National Forest Road 447.
2.0	33.8	T-intersection (National Forest Road 848 and National Forest Road 447). TURN RIGHT onto National Forest Road 447.
0.6	34.4	Cross Bay Creek. This area is called Watkins Ford.
0.4	34.8	Exposure of Pennsylvanian age sandstone overlain by loess on the right.
0.15	34.95	Gravel road changes to a blacktop road.

0.05	35.0	Y-intersection. BEAR LEFT. Follow National Forest Road 447.
1.9	36.9	T-intersection from the right. County Road 94. CONTINUE AHEAD.
0.4	37.3	Millstone water tower on the left.
0.4	37.7	ONE-WAY STOP. T-intersection (National Forest Road 447 and Illinois Route 145). TURN RIGHT. US Route 45 is 15 miles to the left. Lake Glendale is 11 miles to the right.
0.25	37.95	Exposure of Pennsylvanian age sandstone on the right.
1.85	39.8	Crossroad intersection. Enter city limits for Eddyville. CONTINUE AHEAD.
0.65	40.45	Crossroad intersection. CONTINUE AHEAD. Eddyville Road to the left and Main Street to the right. Eddyville is to the right, and the road to the left leads to Golconda.
0.4	40.85	T-intersection from the left (National Forest Road 442). CONTINUE AHEAD.
0.95	41.8	T-intersection from the left (unmarked road). CONTINUE AHEAD.
1.2	43.0	Beginning of long “0.5 mile” exposure of Pennsylvanian age sandstone overlain by loess on the right.
1.05	44.05	Cross Hayes Creek. The drainage from Hayes Creek flows toward Bay Creek.
0.5	44.55	View of Johnson Ridge 5 miles straight ahead.
1.0	45.55	View of Millstone Bluff, 2 miles ahead on the right at one o’clock.
0.4	45.95	Y-intersection. Illinois Route 145 curves 90 degrees to the left. CONTINUE STRAIGHT AHEAD onto Illinois Route 147.
0.25	46.2	T-intersection from the right (National Forest Road 423). CONTINUE AHEAD. Road to the right leads to Bell Smith Springs.
0.3	46.5	T-intersection from the right (National Forest Road 463). CONTINUE AHEAD. Road to the right leads to Bay Creek No. 5 Lake.
0.8	47.3	T-intersection from the right. Entrance to Millstone Bluff National Register Site. TURN RIGHT.
0.35	47.65	Enter parking lot for Millstone Bluff National Register Site.


7
MILLSTONE BLUFF
8
ALTERNATE STOP
To Alternate Stop 9, Interstate 24, and Vienna
To
Millstone Bluff
MILLSTONE BLUFF
NATIONAL REGISTER SITE
Quarry
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Robbs
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BM 391
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STOP 7: Millstone Bluff National Register Site (SE, NW, NW, Sec. 20, T12S, R5E, 3rd P.M., Glendale 7.5-minute Quadrangle, Pope County).

End of Field Trip. Drive Carefully on Your Way Home.

To reach Interstate 24 and Vienna, exit the parking lot and retrace the route back to Illinois Route 147. Turn right and follow Illinois Route 147 to Illinois Route 146 (approximately 11.5 miles). Turn right onto Illinois Route 146. Entrance ramps for Interstate 24 are just ahead. Vienna is west of Interstate 24.

ALTERNATIVE STOPS

Alternative STOP 8: Railroad cut at Robbs (SW, NW, SW, SE, Sec. 19, T12S, R5E, 3rd P.M., Glendale 7.5-minute Quadrangle, Pope County).

From Millstone Bluff, the Robbs railroad cut is 0.5 miles west of the entrance road. To observe the chevron fold, park along Bull Pen Road, which is located immediately east of the railroad overpass. The railroad cut is west of Bull Pen Road. The folded rocks are approximately 0.35 miles south of Illinois Route 147.

Alternative STOP 9: Mississippian Menard Limestone (NW NE SW Sec. 3, T135, T3E, 3 rd P.M., Johnson County, Bloomfield 7.5-minute Quadrangle).

This stop is located east of Vienna along the Interstate 24, westbound entrance ramp. Exposure of Mississippian Menard Limestone along the east and northeast sides of the Interstate 24 access ramp. This locality provides an area that is easily accessible and is a good fossil collecting location.

STOP DESCRIPTIONS

STOP 1: Round Bluff Nature Preserve, Ferne Clyffe State Park (NE, SW, Sec. 27, T11S, R2E, 3rd P.M., Goreville 7.5-minute Quadrangle, Johnson County).

Bedrock strata exposed in the park belong to the Caseyville and Tradewater Formations of lower Pennsylvanian age (fig. 2). Bedrock in this area dips to the north-northeast.

Round Bluff Nature Preserve Trail

The following descriptions were modified from a park brochure and combined with field notes.

On the Round Bluff Nature Preserve trail you will be walking around a mesa-like sandstone knoll with vertical cliffs ranging from 50 feet to 100 feet in height. The trail offers visitors a variety of viewing opportunities. The bright crisp colors of fall foliage and the panoramic delights of the spring are only a small part of what nature displays in this area. Nature preserves such as this one are important because they provide homes for wildlife and plants, and supply us with clean air and scenic beauty. It is our responsibility to take care of these areas for future benefits.

Please remember that visitors to state parks are encouraged to "leave no trace"of their visit.

Stations along the trail help identify unique habitats and communities For your safety, stay on the designated trail. Please remember that the plants and animals in this area are protected by law. Do not disturb or remove any of the species that exist within this area. Along the trails are evidence of some slope instability; look for trees with J-shaped trunks at the base.

Station 1. An Evergreen Twist The gnarled, twisted trees you have just passed are eastern red cedar. This evergreen tree is resistant to extremes of drought, heat, and cold. This species is commonly found in old fields, dry uplands, and on rock outcrops. Red cedar is considered a pioneer species, that is, one of the first trees to enter an area following a disturbance. These red cedars are growing along an old road bed. Other tree species include hickory, ash, oak, and maple. This station is along the western edge of Round Bluff, where an abundance of ferns, moss, and lichen thrive under the canopy provided by the trees.

Station 2. An Ancient Bluff Round Bluff is a 280- to 320-million-year-old sandstone knob. Pounds Sandstone is a sedimentary rock consisting mostly of rounded grains similar to the sand of a river bed. This type of sandstone is more durable than the surrounding material. Years of wind and water erosion have "eaten" away surrounding material and caused the separation of the sandstone from surrounding formations. Notice the joint-controlled erosion at this stop. The funneling of water along the joint surface has increased the rate of erosion (fig. 7).

Figure 7 Increased erosion along a joint in Pounds Sandstone at trail marker no. 2, along the Round Bluff Nature Preserve Trail (photo by Wayne T. Frankie).

Between stations 2 and 3 notice any changes in vegetation. Although the geology has remained the same, several factors differ. The trail has moved from the western edge to the southern edge of Round Bluff, and the mosses and ferns have all but disappeared. The south-facing edge of Round Bluff is drier because of the increased amount of solar energy from the sun. In addition, the bedrock dips to the north, which controls the movement of groundwater to the north, away from the southern edge of the bluff.

After this station, a sign on the left indicates the state champion winged elm tree. This is the largest specimen in the state. Although most winged elm trees grow to around 1.5 feet in circumference, the champion tree is 5 feet in circumference.

Station 3. Almost a Desert A glade is an opening in the forest that usually includes a mixture of stunted trees, shrubs, and open areas with little or no vegetation. The thin soil and extremely dry site conditions are caused by bedrock occurring at or near the surface. This particular site is a sandstone glade (specifically called a sandstone barren; see fig. 8). Dominant plant species include blackjack oak, winged elm, little bluestem (grass), and farkleberry (shrub). Prickly pear cactus, the only cactus found in the state, can also be found in these glade communities. A small amount of iron cementation is visible in the sandstones. Note that this sandstone bluff faces south. Compare this bluff with the north-facing bluffs at trail marker no. 5. The sandstone barrens provide a unique and very restricted habitat for the lichen grasshopper (fig. 8). These sandstone barrens along the Pennsylvanian Escarpment are the only place in the world where the lichen grasshopper occurs. The grasshopper's habitat is limited to a narrow (10-mile-wide) swath extending from the far eastern edge of Missouri, through Illinois, and into a portion of western Kentucky. This relationship between the lichen grasshopper and the sandstone barrens demonstrates the relationship between geodiversity and biodiversity.

Station 4. A Continuous Water Source To your left, under the shelter bluff, you can see a small pool of water that is the only continuous spring within the Round Bluff Nature Preserve (fig. 9). This spring may be small, but it has provided a much-needed supply of water for green frogs and many other forms of wildlife, especially in times of drought. Why do you think the spring is located at the base of the bluff? What geologic factors are at work here? An example of honeycomb weathering is exhibited near the rock shelter. Trail marker no. 4 is on the east side of the bluff.

Figure 8 Closeup view of camouflaged lichen grasshopper on Pounds Sandstone. Sandstone barrens at trail marker no. 3 on the north side of Round Bluff Nature Preserve (photos by Wayne T. Frankie).

Figure 9 Spring at base of rock shelter in Pounds Sandstone at trail marker no. 4, along the Round Bluff Nature Preserve Trail (photo by Wayne T. Frankie).

Wherever there is a joint in the rocks, the amount of vegetation increases. As you continue toward station no. 5, examine the joints and the associated vegetation (fig. 10). Do the plants increase or slow the rate of erosion?

Station 5. Ferns and Cliffs As a nature preserve, Round Bluff possesses four relict species. A relict species is one that occurs in a small, disjunct population. Two of the area's four relict species can be found in this sandstone cliff community. As you can see, many different species of fern exist along this cool, moist vertical exposure of resistant bedrock. Note: this is a north-facing bluff. Are there any differences between this site and the site at trail marker no. 3?

Located just before trail marker no. 6 are a number of large tilted sandstone blocks on the ground. Look up at the top of the cliff face. Do you see any connection?

Station 6. Elegant Beauty From this vantage point, during February through May, you will see an exceptional spring wildflower display. Wildflowers take advantage of the sunlight on the forest floor before the trees leaf out in the spring. Some of the most elegant flowers to look for during these months are Dutchman's breeches, Jack-in-the pulpit, and toothwort.

Geologic History

The Shawnee Hills took millions of years to form. The rock formations and cliffs are made of sandstone and are about 320 million years old. Long ago most of Illinois, western Indiana, and western Kentucky were covered by a great inland sea. For millions of years, great rivers carried sand and mud to the sea where it settled along the shoreline. Over time, the weight of the sediments turned them into layers of rock, thousands of feet thick. In southern Illinois, these sediment layers were over 20,000 feet thick, or about 4 miles deep.

Eventually uplift raised the land well above sea level. The uplift also fractured the bedrock, exposing it to nature's erosive forces. Since that time, windblown sand, rain, and freezing and thawing have worn down the layers of sediment, creating the beautiful, interesting rock formations within the Shawnee Hills.

Figure 10 Abundance of ferns growing along a joint on the moist north side of the Round Bluff Nature Preserve near trail marker no. 5 (photo by Wayne T. Frankie).

The sandstones of the Caseyville Formation are very resistant to erosion, and wherever they are exposed, they are cliff-formers. The sandstones represent both river channel sands laid down by an ancient Pennsylvanian river system that crossed this part of Illinois from northeast to southwest and also lower delta nearshore, brackish to marine deposits. A number of sedimentary structures, formed by river currents within a delta system building out into and along a shallow continental sea, are well developed in the Pounds Sandstone. These sedimentary structures include wedge-shaped cross-bedding and ripple marks. The purity and coarseness of the sandstone indicate that the currents along the shallow seashore (both river and nearshore currents) were swift and that much of any fine material and non-quartz-grain materials were sorted out before deposition. Other sedimentary features include graded bedding, bimodal sorting of the medium- to coarse-grained sandstone containing white quartz pebbles, and Liesegang banding.

Interpretation of the Pennsylvanian Environment

The origin of the Caseyville was thought to be mainly fluvial (river) deposits. Research conducted in the late 1980s collected evidence indicating that a larger percentage of the Caseyville was deposited in nearshore, brackish to marine conditions (paralic) (Devera 1986, 1989; Devera et al. 1987). Evidence from trace fossils, sedimentology, and the geometry of these sandstones all supports the paralic deposition of these rocks.

Liesegang Banding The unusual concentric and parallel Liesegang banding of iron oxide-rich layers in sandstone, which is so common on outcrops of the Caseyville, can be found throughout the Pennsylvanian Escarpment. Geologists generally attribute this banding to the so-called "Liesegang phenomenon" in which laminated or banded precipitate results when a salt-containing fluid is introduced into a colloidal suspension within a porus medium (such as this coarse sandstone). Precipitation occurs at regular intervals during mixing of the fluid and the colloid when the dissolved salt reaches a supersaturated level.

PENNSYLVANIAN SYSTEM

Tradewater Formation

Ferne Clyffe Member Siltstone, shale, sandstone, and coal. Siltstone, light to dark gray, micaceous, local concentrations of carbonaceous plant material; interbedded with and grading into shales and thin-bedded sandstones. Shale, light to dark gray, micaceous, slightly silty, interbedded with siltstones and thin sandstones. Sandstone, whitish tan to yellow-orange, fine grained, argillaceous; typically thin-bedded, lenticular, locally becoming massive, with large-scale trough and planar cross-bedding; thin-bedded facies commonly interbedded with siltstones and shales. The Reynoldsburg Coal Bed, near the base of the unit, is lenticular and up to 3 feet thick. The Ferne Clyffe is usually poorly exposed. Thickness of 30 to 40 feet.

Caseyville Formation

Pounds Sandstone Sandstone, light tan to rusty tan, with purple and reddish mottling, fine to coarse grained, very clean and well-sorted, scattered quartz pebbles; local zones of quartz pebble conglomerate; typically massive-appearing, varying from medium- to massive-bedded, common trough to planar cross-bedding, well-jointed; shows characteristic honeycomb weathering. Forms large bluffs 40 to 70 feet high across the southern part of the Goreville Quadrangle. Thickness of 40 to 100 feet.

Unamed interval below the Pounds Sandstone Siltstone, shale, and sandstone. Siltstone, light to dark gray, micaceous; thinly laminated, locally interbedded with silty shales and thin argillaceous sandstones. Shale, light to dark gray, micaceous, slightly silty, weathers fissile; grades locally into siltstone. Sandstone, light grayish tan to yellowish orange, fine to medium grained, locally coarse grained, zones of quartz pebbles, fairly clean and well sorted except where interbedded with finer clastics; thin to thick ripple-marked bedding, the latter with trough and planar cross-bedding. One of these sandstones, the Dutchman Creek sandstone lentil, forms ledges. Only the Dutchman Creek sandstone is readily exposed in much of the area. The finer facies are commonly slumped and covered. Thickness of 50 to 70 feet (Jacobson 1991).

An examination of the exposed strata near the entrance to some of the box canyons shows that the joint system noted in the Pounds and the Ferne Clyffe Sandstones is also present in the basal unnamed interval below the Pounds Sandstone. This presence proves that the jointing is a superimposed structure formed by crustal forces affecting this whole region rather than a peculiar characteristic of a particular rock type. Crustal forces producing this type of structure probably occurred after the close of the Pennsylvanian Period but before the deposition of Cretaceous sediments in extreme southern Illinois.

The small streams here erode the weak unnamed interval below the Pounds and wash it out from under the Pounds Sandstone, producing a characteristic overhang. In addition, the shale tends to part into thin sheets that easily slip past one another because the clay minerals forming the shale are slick when wet. This lubricated surface allows massive blocks of the overlying Pounds Sandstone to slide away slowly from the cliff face. The sizes of the sandstone blocks are determined by the joints and fractures present within the sandstone body.

Ferne Clyffe State Park

Known as an outstanding natural scenic spot for nearly 100 years, the park contains an abundance of ferns, unique geologic features, and unusual plant communities that create an atmosphere that enhances the many recreational facilities offered at the park. Trails wind through picturesque woods, allowing visitors to view fascinating rock formations and inspiring vistas.

George Rogers Clark and his contingent purportedly passed through or near Ferne Clyffe on their march to Fort Kaskaskia in 1778. One hundred years later, the Cherokee are reported to have used the area as their hunting range while on their Trail of Tears march.

Two Cairo brothers purchased a part of the park known today as Hawks' Cave/Big Rocky Hollow in 1899 and called it Ferne Clyffe because of the ferns that grew in such abundance. The area soon became known for its beauty and was eventually sold to Miss Emma Rebman, a local school teacher and Johnson County school superintendent. Miss Rebman opened the park to the public on Sundays for a 10-cent admission. Ferne Clyffe soon became a popular attraction, and local entrepreneurs began to provide transportation from the Goreville train depot for an additional 10 cents. In 1929, Miss Rebman offered to sell the park to the state of Illinois. Additional efforts by conservation and political groups such as the Greater Egypt Association and the Illinois Redevelopment Board resulted in the state's purchase of Miss Rebman's 140 acres in 1949.

Today, Ferne Clyffe State Park covers 2,430 acres of the majestic Shawnee Hills and is visited by more than 200,000 nature lovers each year.

Natural Features Impressive rock formations can be seen from almost all of the park trails, but two of the best-known sights are Hawks' Cave, a 150-foot-long shelter bluff, and a 100-foot-tall intermittent waterfall on the Big Rocky Hollow trail.

Flora and Fauna It would be nearly impossible to list all of the plant life that thrives in the park—there are more than 700 species! Flowering dogwood, redbud, serviceberry, spicebush, sumac, sweetgum, maple, oak, hickory, and some of the woodland wildflowers create an extraordinary color backdrop for recreational activities in the spring and fall. Late April and early May are particularly good times for viewing the springtime color show. Fall foliage is at its best in October.

As you walk the trails, you can expect to see squirrels, rabbits, doves, quail, bluebirds and other songbirds, and an occasional wild turkey. Fishermen will be impressed by populations of largemouth bass, bluegill, channel catfish, and redear in the lake.

Ferne Clyffe Lake Since 1960, the 16-acre Ferne Clyffe Lake has offered visitors additional recreational and scenic opportunities. The lake has a maximum depth of 22 feet, and a hiking trail encompasses the 1-mile shoreline. The lake is open to bank fishing, but boating and swimming are prohibited. Spectacular views of the lake can be seen from Lakeview Picnic Shelter and Blackjack Oak Trail.

Just south of the Lakeview Picnic Shelter is the 53-acre Round Bluff Nature Preserve. This area is a marvelous mix of unique geologic features and unusual plant communities. Each season brings its own beauty to the area, but spring and fall are the most colorful seasons. Dutchman's breeches, trillium, spring beauty, trout lily, and other woodland wildflowers add vibrant color to the ground cover in the spring. Fall's colder temperatures change the deep greens of the summer tree foliage to a spectacular mix of reds, purples, golds, and browns that cover every hillside.

STOP 2: Hawks' Cave, Ferne Clyffe State Park (SW, NE, SW, Sec. 21 T11S, R2E, 3rd P.M., Goreville 7.5-minute Quadrangle, Johnson County), is located along Hawks' Trail in Ferne Clyffe State Park.

Follow Hawks' Cave Trail, an easy 0.5-mile trail that leads visitors past one of the largest rock shelter bluffs in Illinois (fig. 11). Once on the trail, follow the first trail junction to the right. Hawks' Cave is a rock shelter formed within the Pounds Sandstone.

Caution: When climbing on the large sandstone blocks, the loose dry sand from the Pounds Sandstone can make footing very unstable. The well-rounded quartz grains act like ball bearings underfoot.

Creating a Rock Shelter: Groundwater Sapping

In many stream valleys, the flow of groundwater into the stream enhances the breakdown of rock along the valley bottom. The exposure of a vertical cliff face allows this process to perform its role in the open. When groundwater seeps out of a cliff face or hillside, it can undermine the cliff or slope in a process called groundwater sapping. Erosion at the seepage face creates an alcove and, as the back of the alcove retreats, the overhanging rock is undermined and eventually collapses. Over time, the entire cliff face retreats. Surface water plays an important role in this process by removing the debris created by sapping.

The process is complicated by variations within the rock that affect the flow of groundwater. Changes in the permeability of the rock enhance the groundwater flow in certain areas, which enhances weathering and erosion. Sapping alcoves commonly occur above rock layers with low permeability. Other geologic variations, such as fractures or undermining by a stream, can cause groundwater flow to focus on a small area of the cliff face. This focusing causes that section of the cliff face to erode and retreat more rapidly, which results in the formation of a canyon.

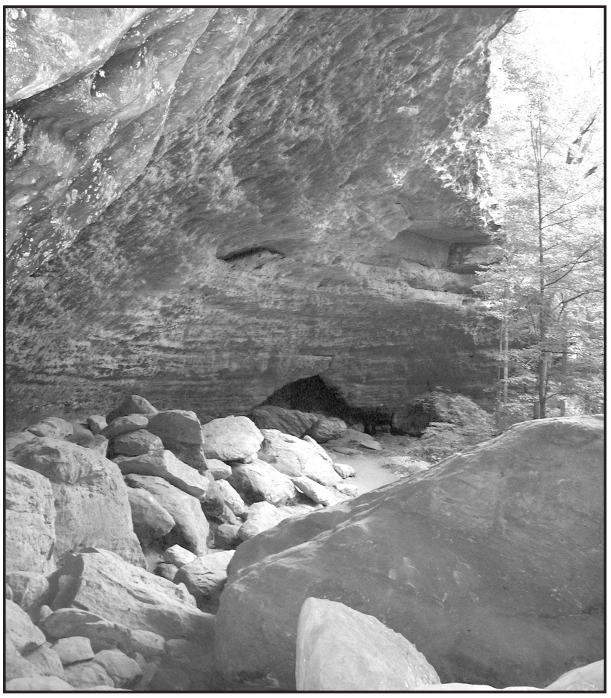


Figure 11 Hawks' Cave at Ferne Clyffe State Park at Stop 2 (photo by Wayne T. Frankie).

Areas where groundwater sapping is a dominant erosional process display several distinctive features. Seepage zones occur above layers of low permeability and generally are covered with algae or moss; they are usually most active in the spring

and may dry up completely in the fall. The alcoves may be very small (centimeters) to very large (meters or tens of meters), and they often have slightly arched roofs. The alcoves always have seepage zones in the back. Sapping canyons have vertical sides and an amphitheater-shaped head. The walls of the sapping canyon often contain many seepage zones and alcoves, and a very large alcove is usually located at the head of the canyon.

Many of the sandstone shelters scattered throughout southern Illinois were used by Native Americans as both long-term and short-term homes. In Arizona, some very large alcoves contain cliff dwellings built where they are shaded from the sun and cooled by the evaporating seep water, and some small alcoves have been sealed off by the Navajo to collect the seep water for drinking.

Little Rock Shelter

A small rock shelter is located immediately east of the larger Hawks' Cave. This rock shelter has a well developed joint in the ceiling that extends along the full length of the overhang. This joint is approximately 20 feet back from the front of the overhang. What effect will this joint have on the development of this rock shelter? Four joints or pressure release cracks can be seen on the east end of the shelter.

Examine this feature closely. Later on today, we will visit a natural arch at Bell Smith Springs and discuss the similarities between these two geologic phenomena.

As you follow the trail past Hawks' Cave and head back toward the trailhead you pass over a small creek. Examine the rocks deposited within the creek. Do you notice anything different about these rocks compared with most sediments that are normally deposited in a stream? The stones are aligned in a specific direction, indicating the direction of the flowing water. Notice that the flat face on many of the rocks point in a direction upslope or (dip) of the stream. This depositional feature, known as imbricated rocks (shingle structure), is useful for interpreting ancient environments within sedimentary rocks. This feature is a good example demonstrating the theory of uniformitarianism, which simply stated is "the present is the key to the past," If a geologist finds imbricated clasts within a layer of strata, he or she can determine the direction that the water was flowing, thus helping the geologist understand the ancient depositional environment.

STOP 3: Waterfall, Ferne Clyffe State Park (SW, SW, SE, Sec. 22 T11S, R2E, 3rd P.M., Goreville 7.5-minute Quadrangle, Johnson County), is located along Big Rocky Hollow Trail in Ferne Clyffe State Park.

Follow Big Rocky Hollow Trail, an easy hike with a round-trip distance of 0.75-mile. The trail leads to a 100-foot-tall intermittent waterfall (fig. 12). The waterfall is developed in the Pounds Sandstone. What type of features are found along the trail to the waterfall? Things to look for are joints, large isolated blocks of sandstone, rock shelters, springs, and indications of active slope movement.

Along the trail leading to the waterfall, trees with a classic J-shaped bend in the lower portion of the trunks near the base of the tree indicate mass movement.

The waterfall is developed at the head of a sapping box-shaped canyon. The circular shape of the

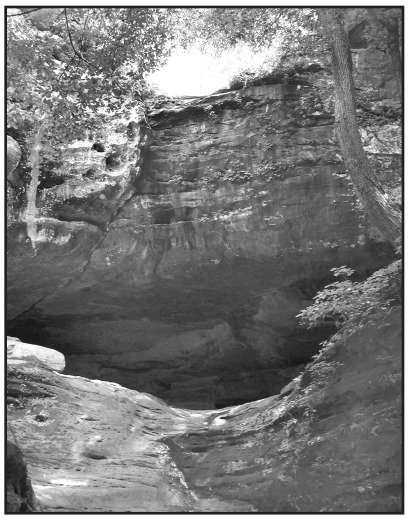


Figure 12 Intermittent waterfall at the end of Big Rocky Hollow Trail, Ferne Clyffe State Park at Stop 3 (photo by Wayne T. Frankie).

waterfall contains at least four joint planes. Approximately 50 feet from the top of the falls, near the middle, is a small rock shelter or alcove. A second alcove occurs at the base of the waterfall. The sandstones near the base contain both planar and cross-beds. Medium to large quartz pebbles are visible in the Pounds Sandstone on the underside of the lower alcove. The honeycomb texture present within the Pounds Sandstone is a result of differential erosion.

STOP 4: Southern Illinois Stone Company, Buncombe Quarry (NW, Sec.11, T12S, R2E, 3rd P.M., Vienna 7.5-minute Quadrangle, Johnson County).

You MUST stop at the office to secure permission to enter this property.

Mississippian age Kinkaid Limestone Formation and overlying Wayside Member of the Pennsylvanian age Caseyville Formation are exposed here (figs. 2, 13, and 14).

PENNSYLVANIAN SYSTEM

Caseyville Formation

Battery Rock Sandstone Member Sandstone, light tan to yellow-orange with reddish mottling, fine to coarse grained, clean and well-sorted, scattered quartz pebbles; occasional zones of quartz pebble conglomerate; thin- to massive-bedded, common trough and planar cross-bedding; form large bluffs across much of southern Illinois. Although not exposed in the quarry, this sandstone occurs to the north.

Wayside Member Interbedded siltstone, shale, sandstone, conglomerate, and coal. Siltstone, laminated light to dark gray micaceous, locally carbonaceous to almost coaly; sometimes interbedded with shale and fine-grained, argillaceous, thin-bedded sandstones. Shale, light to dark gray, micaceous, locally carbonaceous; locally grades into siltstone. Sandstone, white to light grayish tan to yellowish tan or yellowish orange; fine to coarse grained, sometimes argillaceous, local zones of quartz pebbles, shale, and siderite pebble lag deposits; thin- to medium-bedded, thin sandstones, ripple marks, load casts, and tool marks are common, often interbedded with siltstones and shales. Lower contact is a major unconformity.

Figure 13 Southern Illinois Stone Company, Buncombe Quarry, at Stop 4 (photo by Wayne T. Frankie).

MISSISSIPPIAN SYSTEM

Kinkaid Limestone Formation

Goreville Limestone Member (upper limestone) Twenty to 30 feet thick, light to medium gray to brownish gray to dark gray, crinoidal packstone and grainstone that are medium to coarse grained. Beds are 4 to 24 inches thick; argillaceous, containing local chert beds and nodules; medium- to thin-bedded; commonly interbedded with calcareous gray shale; contact is sharp.

Cave Hill Member Interbedded limestone, shale, and claystone. Limestone is light to dark gray lime mudstone to fine-grained skeletal packstone that weathers to light gray; it is dense and fossiliferous. Chert lenses and beds up to 12 inches thick are present in the lower part. Clay shale is

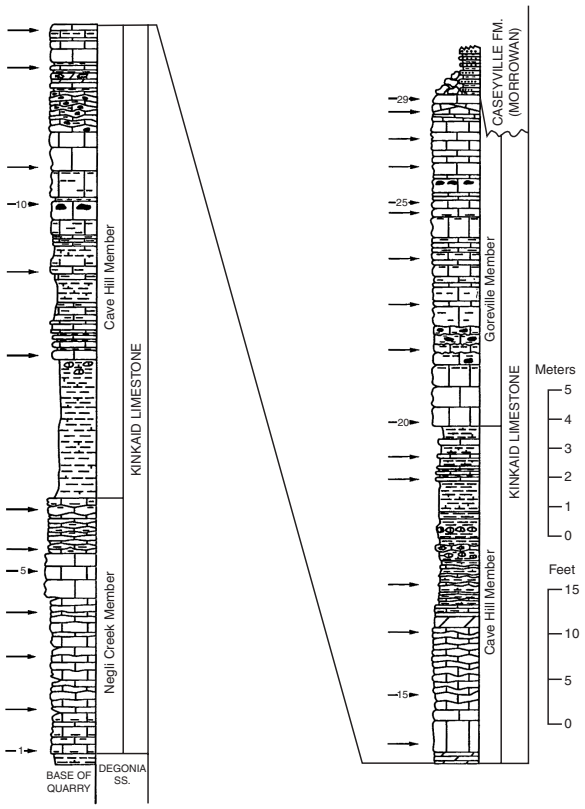


Figure 14 Stratigraphic section of Mississippian and Pennsylvanian strata exposed in Southern Illinois Stone Company's Buncombe Quarry at Stop 4 (photo by Wayne T. Frankie).

dark greenish gray, dark gray, and black, soft to hard, well laminated, calcareous, and fossiliferous. Claystone, greenish gray and red variegated, occurs at the top of the unit; lower contact is sharp.

Negli Creek Limestone Member Limestone; lower part of the unit is dark brownish gray, fine-grained, argillaceous, cherty lime mudstone and wackestone that contain bellerophontid gastropods and *Girvanella* sp. oncoids. The upper part is light to medium gray, fine to coarse grained, argillaceous, crinoidal packstone and grainstone; lower contact is sharp.

Degonia Formation Not exposed, occurs just below the lowest bench within the quarry. Interbedded sandstone, siltstone, shale, and claystone. Siltstone to very fine sandstone is bluish, greenish, and olive-gray, laminated, brittle, and locally burrowed. Silty shale is gray to greenish gray and laminated; clay shale is dark gray and platy. Claystone is dark greenish gray, olive-gray, and red mottled, mainly at the top of the unit; lower contact is sharp (Jacobson 1991, Nelson 1995).

The Kinkaid Limestone is the youngest and northernmost limestone-bearing formation of consequence in extreme southern Illinois. This formation extends across southern Illinois just beneath and south of the Pennsylvanian Escarpment in an eroded outcrop band 1/8 to nearly 2 miles wide, except locally, where it has been eroded away. Although the Kinkaid consists primarily of limestone, prominent shale units are generally present. The Kinkaid is partially eroded and generally is less than 50 feet thick to the west in Union County. Across the state in eastern Hardin County, the Kinkaid is thin or absent because of erosion. In western Hardin County and eastern Pope County, the formation attains a maximum thickness of about 200 feet, about half of which is shale. Thicknesses of 140 feet have been reported in Johnson and western Pope Counties. Here, in the central area, the formation apparently contains its greatest continuous thicknesses of limestone and is locally overlain by the Grove Church Shale. At least part of the irregular thickness of the Kinkaid Formation is a result of erosion before the overlying Pennsylvanian strata were deposited.

Limestones in the Kinkaid generally are gray to dark gray to black, fine- to medium-grained, well-bedded in strata less than 3 feet thick, more or less siliceous, locally cherty, and may contain small pyrite crystals. The chert may be disseminated throughout portions of the limestone, or it may occur in beds. Some of the chert is black. In this area, a prominent shale unit 10 to 15 feet thick occurs about 40 to 50 feet below the top of the limestone.

The overlying Pennsylvanian Wayside Sandstone Member of the Caseyville Formation is conglomeratic in the lower part. Flattened discoidal light brown fine-grained sandstone stringers and chert pebbles occur in a light gray medium-grained sandstone matrix. This unit also contains thinly laminated light gray and medium gray siltstone. Compressed carbonized plant remains are common.

In this quarry, stone is trucked from the quarry face to the processing plant, where it goes through a series of crushers and screening towers that reduce the coarse, pit-run stone to material of more uniform size. Coarser stone is used for concrete aggregate and road stone. Finer grades are used in macadam (asphalt) surfacing, and the finest crushed stone is used for agricultural lime. Finished stone is currently shipped by truck, and, in the past, it has been shipped by rail.

Limestone is one of the most important and valuable non-fuel mineral resources in Illinois. The best sources of this material are in northern, western, and extreme southern Illinois. In these localities, the stone is of high quality, can be used for more purposes, and therefore is in great demand. Although limestones do occur in Pennsylvanian strata that cover approximately four-fifths of the state, the less pure, weaker Pennsylvanian stone generally has fewer applications. Nevertheless, Pennsylvania stone is used for some purposes because it is the closest available stone.

The construction industry uses large quantities of stone as raw materials for making cement, concrete, and macadam aggregates; road and railroad surfacing; and for riprap. Large quantities are also used for agricultural lime to "sweeten" soil. Because of its bulk and weight, stone is too expensive to transport over long distances, except for special uses in the chemical industry. Municipalities and industries that have extensive supplies nearby are fortunate. The Southern Illinois Stone Company quarry is one of the largest quarries in this part of the state.

History of Southern Illinois Stone Company

(Information provided by Delta Companies, Inc.) Production of rock began here on September 2, 1949, under the name of G and R Stone Company. Production at that time was 150 tons per hour, there were13 employees, and the payroll was $800.00 per week. On September 5, 1950, the company reorganized and became Southern Illinois Stone Company, which was incorporated into Delta Companies, Inc.

Currently the Southern Illinois Stone Company employees 26 union and 9 company staff. Production now is 1,000 tons of crushed stone per hour with 25 different types of products available including everything from aglime to 2,000-pound boulders. Yearly production totals now reach more than 1.4 million tons, with sales of 1.3 million, for all of southern Illinois from Effingham County to the north and from the Mississippi River to the Ohio River, east and west.

In Illinois, Southern Illinois Stone Company was a major supplier in both Interstates 57 and 24. A division of the company built portions of the Pan American Highway. The company also resurfaced streets in the French Quarter of New Orleans before the World's Fair.

Delta employs 325 to a seasonal high 600 employee in southeastern Missouri, southern Illinois, and northeast and central Arkansas. Revenues exceed $100,000,000 annually. Its customer base includes the state highway departments of Missouri, Illinois, and Arkansas as well as area cities, counties, and hundreds of contractors and businesses. Further testament to the local significance of Delta Companies, Inc. is its continued commitment to local civic projects such as Riverfest, youth baseball, softball and soccer, United Way, Boy Scouts, Girl Scouts, Special Olympics, and all of the local Chambers of Commerce.

Today, Southern Illinois Stone Company, its parent company, and its affiliates are involved in an expanding market. Along with growth come ever increasing environmental issues and regulations. The company tries to do its part to preserve the natural habitat of southern Illinois.

STOP 5: Tunnel Hill (SE, SE, NE, Sec. 35, T11S, R3E, 3rd P.M., Creal Springs 7.5-minute Quadrangle, Johnson County).

View a shale and sandstone sequence near the northern tunnel portal of the abandoned Norfork & Southern Railroad at the southern edge of Tunnel Hill. The sequence contains trace fossils. Bedrock exposed near the southern tunnel portal consists of a thin shale sequence overlain by a massive sandstone (fig. 15). Compare the two sequences of rocks at the entrances to the southern and northern tunnel portals. Are differences related to faulting or the natural dipping of the bedrock? Note: the abandoned railroad and the tunnel are parallel to the axis of a small unnamed syncline mapped by Jacobson (1991).

Stratigraphy and Lithology

A dark gray, silty shale grades upward from the base of the railroad cut into a medium to light gray, shaly siltstone. Evidence of disturbance by living organisms, known as *bioturbation,* increases upward as does the grain size. At the top is a thinly bedded, very fine-grained sandstone that has shaly interbeds; the unit is about 10 feet thick and contains abundant ichnofossils. Another dark gray shale lies above the sandstone unit; it is thinly laminated and contains siderite nodules. The second shale unit is about 15 feet thick and part of another coarsening-upward sequence. Above the second shale is a light gray, very fine-grained shaly quartz sandstone that contains numerous ichnofossils and shale clasts. It grades upward into a medium gray, fine-grained, nonshaly, clean quartz sandstone.

Trace Fossils

The following was modified from the Tunnel Hill Geological Science Field Trip (Reinertsen et al. 1978).

This stop provides an opportunity to look at preserved traces of animal activities—a trail, burrow, or resting place produced by organisms that lived millions of years ago. Trace fossils are also called ichnofossils *(ichnos* is Greek for footprint or track).

By studying ichnofossils, geologists learn how ancient animals and plants lived and interacted with their environment. Trace fossils can help the geoscientist reconstruct ancient geographic settings, interpret environments and conditions of sedimentary deposition, and predict the location of resources. Ichnofossils also indicate the shapes of organisms, such as sea anemones and worms, that are not generally preserved in the fossil record because they lacked hard parts.

Figure 15 Thin-bedded Pennsylvanian age shale sequence near the north portal (Left) and thick-bedded Pennsylvanian age sandstone sequence near the south portal of abandoned railroad tunnel at Stop 5 (photo by Wayne T. Frankie).

The trace fossil of a trilobite trail is like a "snapshot," showing the spatial relationships that existed during the origin of the trail. For example, 300 million years ago, a trilobite crossed a sandy rippled surface on the sea floor and left a trail. Shortly afterward, the trail was buried by more sediment and became fossilized. Today, stream erosion has exposed the spot where the trilobite crossed. We can see where, how, and possibly why the trilobite turned to avoid a certain obstruction.

Studying ancient animal behavior is not as easy as with plant, shell, and bone body fossils that are more commonly collected. Body fossils can be moved out of position after fossilization and reincorporated into younger sediments, which does not happen with trace fossils. Also, many trace fossils are found in rocks, such as the lower Pennsylvanian sandstones in the Illinois Basin, which have relatively poor potential for preserving body fossils.

On this field trip, we will examine trace fossils and rocks for evidence of various depositional systems or ancient environments. Trace fossils are particularly useful in identifying a variety of environments in which soft bodied animals live, including coastal swamps, shallow seas, tidal channels, estuaries, and bay fills. We will also observe, and perhaps collect, some delicate traces left by soft-bodied organisms.

Ichnofossils

Trace fossils found in the lower siltstone-sandstone facies are *Conostichus broadheadi, C. stouti, Asterosoma* sp., *Teichichnus* sp., *Sclarituba missouriensis,* and *Rhizocorallium* sp. Trace fossils found in the upper shaly silty sandstone facies are *Conostichus* sp., *Asterosoma* sp., *Eiona* sp., *Cylindrichnus* sp., and *Sclarituba missouriensis*.

The ichnofossils *Conostichus* and *Asterosoma,* made by burrowing sea anemones (Chamberlin 1971, Devera 1989), and *Rhizocorallium,* probably produced by a *polycheate worm,* indicate marine conditions during deposition. The most likely environment of deposition was an open bay or a shallow shelf sand body near a *distributary* mouth bar. These types of environments commonly develop upward-coarsening cycles.

Interpretation of the Pennsylvanian Environment

The coarsening-upward sequences, with grain size increasing upward, represent infilling of a localized basin or bay and indicate that sediments were deposited in progressively shallower water, with a progressively higher energy environment, in a standing body of water (ocean, lake, or pond) rather than in a flowing stream.

The upward increase in the amount of bioturbation indicates that the rate of deposition was gradually decreasing, allowing burrowing organisms more time to churn through the sediments. Increased bioturbation also could mean a higher influx of organic material from land and thus larger numbers of burrowing organisms in these environments.

Traces of sea anemones and polycheate worms increased biologic activity upward, and increased grain size upsection, all reaffirm an interpretation of a nearshore marine environment like that of an open bay.

Tunnel Hill State Trail

At one time, the rumble of freight cars reverberated through the narrow tunnel. Wooden trestles, with their system of slanted supports and horizontal crosspieces, spanned numerous bluffs and creeks. Passengers in Pullman cars clocked the miles with these and other landmarks as they traveled one of southern Illinois' most scenic routes. Today, the railroad is gone. The route, known as Tunnel Hill State Trail, remains.

Tunnel Hill State Trail stretches for 45 miles from Harrisburg to Karnak, with 2.5 miles being managed by the city of Harrisburg. A trail spur continues on for 2.5 miles from Karnak to Cache River State Natural Area, Henry Barkhausen Wetlands Center, on the old Chicago and Eastern Illinois railroad bed.

The 9.3-mile section between Tunnel Hill and Vienna crosses trails already known to outdoor recreationists: the River-to-River Trail, which extends from the Mississippi to the Ohio River; the unmarked American Discovery Trails, which in southern Illinois follow back roads and some

of the River-to-River Trail; the U.S. 76 Bicycle Route, a part of the Trans America Bike Route; and the Trail of Tears, the primary route the Cherokee Indian tribe took in the winter of 1838–1839 during their forced move from the Great Smokies to Oklahoma.

History

The nation's history and economy are entwined with nineteenth century railroad construction since the federal government made land available to the states for developing a cross-country railway system. Among the developers in Illinois was a hapless Civil War general, Ambrose Burnside, perhaps best remembered for his style of facial hair, for which his compatriots transposed the syllables of his last name to create the term "sideburns." In 1872, Burnside and others began the Vincennes and Cairo Railroad, named for its terminuses at Vincennes, Indiana, and Cairo, Illinois. In addition to passengers, the railroad transported coal, salt, wood products and orchard-grown peaches and apples.

The railroad changed hands through the years. Other operators and owners included the Wabash, St. Louis, Pacific; New York Central; Penn Central; Conrail; and, during its most productive years, the Cleveland, Cincinnati, Chicago, and St. Louis line, also known as the CCC & St. Louis or Big Four. The last owners were the Southern Line and, following a merger, Norfolk Southern Railroad.

In 1991, Norfolk Southern gave the State of Illinois the railroad right-of-way between Harrisburg and Karnak, where it had abandoned operations. The Illinois Department of Natural Resources has worked to develop the railroad ballast as a trail for hikers, joggers, and cyclists, surfacing the trail with crushed limestone and gravel, installing privy toilets, and providing drinking water. The first segments of Tunnel Hill State Trail opened in 1998. The trail was completed during fall 2001.

Natural Features

The trail at Harrisburg begins in flat farm country. At New Castle, the old railroad bed enters the Shawnee National Forest purchase area, remaining there for roughly half of the trail's length. By New Burnside, the trail is among bluffs, and south of Vienna it passes through a lush wetland. At Karnak, it emerges from the Cache River State Natural Area's ancient cypress-tupelo swamp.

As one landform melds into another, the countryside offers ever-changing vistas. Woodland wildflowers dot the forest floor each spring, and prairie flowers and grasses lend their beauty to the summer landscape. Contrasting with the profuse greenery of summer, the lack of foliage on the oak, hickory, tulip poplar, cottonwood, and sweet gum trees brings the river valleys and rocky bluffs into sharp focus from late fall to early spring.

Wildlife abounds in this section of the state, and Tunnel Hill State Trail offers habitat to a variety of animals. Bluebirds and other songbirds flit through the trees, while killdeer, dove, quail, and wild turkey also are present in the area. Squirrels often are seen scampering among the tree tops, and white-tailed deer are frequently observed. Less noticed, but having a presence, are red foxes, eastern cottontail rabbits, raccoons, and opossums.

Landmarks

If the 45-mile length of Tunnel Hill State Trail could be seen in cross section, it would taper to its lowest points at either end, with Harrisburg at 370 feet and Karnak at 340 feet above sea level. The highest point is midway at Tunnel Hill, which has an elevation of 680 feet. By mountain standards, it's just a molehill, but the terrain is high enough that railroad builders decided rather than going over it, they'd tunnel through it, giving the landmark its name. Their decision resulted in a comfortable 2 percent grade the length of the trail.

For more than 50 years after the railroad was built, the tunnel was longer than 800 feet, but when a portion of the tunnel collapsed in 1929, the landmark was shortened by 300 feet. Now 543-feet long, it is the only tunnel on the trail. The tunnel is located 1/4 mile south of Tunnel Hill on the trail toward Vienna.

The 23 picturesque trestles along the completed sections of Tunnel Hill State Trail feature decking and side rails, which entice trail users to stop. The trestles range in length from 34 to 450 feet. The

longest is Breeden Trestle, which is also the highest at 90 feet, and is located 2-1/2 miles south of Tunnel Hill.

The trail corridor, which varies from 40 to 200 feet in width, connects numerous communities: Karnak in Pulaski County; Belknap, Vienna, Tunnel Hill, and New Burnside in Johnson County; Stonefort in Williamson and Saline Counties; and Carrier Mills and Harrisburg in Saline County. Each of these communities has parking areas from which hikers, runners, and cyclists can access the trail.

The parking lot with amenities at Harrisburg is city-owned and maintained. Located in Walnut Street and U.S. Route 45, the lot is at the northern end of a 2.5 mile-long, city-owned trail. The Harrisburg trail skirts the city's east side parallel to Route 45 and runs to the city's southeast limits, where it connects to Tunnel Hill State Trail at the intersection of Feazel Street (Pauper Crossing) and the highway.

There also are hamlets along the trail, including Bloomfield, Sanburn, and Ledford. In addition, there are a handful of locations that could be described as ghost towns: Forman, Bender, Rago, Parker City, and New Castle. All serve as landmarks to trail users. Interpretive signs along the length of the trail point out old coal mines and an abandoned sandstone quarry.

Facilities

Tunnel Hill State Trail is a day-use trail. Motorized vehicles, horses, and hunting are not allowed on the trail. Although an experienced cyclist should be able to travel the complete trail in about a day, hikers are advised that the trail does not have camping facilities. Several campgrounds, however, are located nearby. Shawnee National Forest has three campgrounds within 10 miles of the trail: Lake of Egypt, north of the community of Tunnel Hill; and Teal Pond and Bell Smith Springs, both southeast of New Burnside. A fourth, Lake Glendale, is about 15 miles east of Vienna. Also located in the same vicinity as Lake Glendale is Dixon Springs State Park. Two other state park campgrounds are about 10 miles from the trail: Ferne Clyffe, west of the community of Tunnel Hill, and Saline County Conservation Area, southeast of Harrisburg.

The site office for Tunnel Hill State Trail is on Illinois Highway 146 on the east side of Vienna.

For more information about the trail, contact the site superintendent at Tunnel Hill State Trail, P.O. Box 671, Vienna, IL 62995 or phone 618-658-2168.

STOP 6: Bell Smith Springs (SE, NW, NE, Sec. 33, T11S, R5E, 3 rd P.M., Stonefort 7.5-minute Quadrangle, Pope County).

We will hike to the natural bridge, a rock shelter, and springs at Bell Smith Springs Natural Landmark and Scenic Area located within the Shawnee National Forest. Follow the yellow diamond trail.

CAUTION: There are high, unguarded cliffs here and many loose rocks. LOOK where you are going! Do NOT throw or roll rocks.

Bell Smith Springs Trails and Directions

From the upper parking lot at the information kiosk you can begin 8 miles of interconnected trails that include the 3.2-mile Sentry Bluff Trail (blue diamond), the 2-mile Hill Branch Trail (red diamond), the 1.5-mile Natural Bridge Trail (yellow diamond), and the 1.5-mile general area trail (white diamond). The Hill Branch Trail winds along both sides of the small creek and leads to an old grist mill site.

The following directions will lead you to the Natural Arch. At the first junction, the Blue trail splits off to the left. Follow the White/Yellow trail downhill. At the second junction, a short trail segment branches off to the left and leads to a scenic

overlook. Continuing on the Yellow/White trail to the right leads to a set of stones steps that takes you to the base of the bluffs. From there, follow the Yellow trail to the left to the junction of Bay Creek and Spring Branch. Follow the Yellow trail to the north along Bay Creek, and cross Bay Creek at the first rocky ford. Follow the Blue/Yellow trail on the east side of Bay Creek to the left (north). The Natural Arch is located on the east side of Bay Creek, north of the junction of Bay Creek and Spring Branch.

From the base of the stone steps along the Yellow/White trail, follow the White trail to the right past a spring at the base of the bluffs and to the Devil's Backbone. Following the White trail past the Devil's Backbone, take the switchback (leading uphill) on the right. This trail leads to the top of the bluffs overlooking the Devil's Backbone, to the top of the stone stairs, and back to the parking lot.

A second route to the base of the bluffs is to follow the Blue trail, to the left, at the first junction below the kiosks. At the next trail junction on the Blue trail, follow the Yellow trail to the right (sign indicating Jay Gap). There the trail begins its descent to Bay Creek. At the top of the narrow stone steps, follow the Blue/Yellow trail down the steps. Once at the bottom, look at the cross-bedding in the bluff next to the stairs. These are low-angle cross-beds, which indicate a low energy environment.

Continue on the Blue/Yellow trail to Bay Creek, where the trail T's to the right and left. The Blue trail continues to the left, and the Yellow trail is on the right. Cross Bay Creek by following the trails to the right or left. Look for a rocky ford along Bay Creek to reach the other side. The Natural Bridge is on the other side of Bay Creek and to the right of the T intersection. After reaching the other side of Bay Creek, the Blue/Yellow trail follows along the creek. If you follow the Blue/Yellow trail to the left (north) and take the Yellow trail at the switchback (leading uphill), the trail will lead to the top of the Natural Arch. If you follow the Blue/Yellow trail to the right (south), the trail leads to the base of the Natural Arch.

Natural Features

The natural bridge and Devil's Backbone, a series of huge boulders in a clear pool, are the most recognizable features of Bell Smith Springs. There are more than 700 species of flowering plants, ferns, and lichens found at Bell Smith Springs—which represents 20% of the total number of plants and lichens known in Illinois. With the combination of unique plant life and geologic features, Bell Smith Springs has been designated a National Natural Landmark Trail System. Bell Smith Springs is an outstanding location for wildlife viewing. White-tailed deer are abundant. In addition, birders come to the area to find tanagers, pileated woodpeckers, eastern phoebes, sparrows, and several species of vireos.

Bell Smith Springs is surrounded by other scenic spots, including Burden Falls and Bay Creek wilderness areas, Teal Pond, Millstone Bluff archaeological site, Lake Glendale Recreation Area, Trigg Tower, Jackson Hollow, and the River-to-River Trail.

Geology

The Bell Smith Springs Scenic Area lies nearly 2 miles southeast of the drainage divide separating streams flowing north and east to the Ohio River via the Saline River from streams flowing south and east to the Ohio River via Bay Creek. Streams here have incised themselves deeply through the thin soil and loess into the underlying Pennsylvanian bedrock. The upper slopes here are underlain by thin-bedded sandstones and siltstones of the Tradewater Formation. However, the base of these high slopes terminates abruptly at the brink of precipitous cliffs 60 to 70 feet high formed by the massive Pounds Sandstone Member of the Caseyville Formation.

The natural bridge is located on the southeast side of Bay Creek about 500 feet upstream from the junction of its tributary, Spring Branch. This natural bridge is the largest in Illinois, being about 150 feet long, 30 feet wide, and about 60 feet high (fig. 16). At one time, water from the upland flowed

Figure 16 Illinois' largest natural bridge (150 feet long, 30 feet wide, and 60 feet high), Bell Smith Springs, at Stop 6 (photo by Wayne T. Frankie).

across the lip of the cliff on the outside of what is now the bridge and helped to excavate a rock shelter at the base of the cliff, immediately above the underlying unamed interval below the Pounds Sandstone. Eventually, a joint, about 30 feet or more back from the cliff, began to intercept some of the water and funneled it downward behind the cliff face. As time passed, the joint was enlarged, and more water was diverted to speed the erosion process here. Eventually, the enlarged joint intersected the rock shelter and helped to flush some of the shale and smaller rock debris out of it to form the natural bridge. The bridge will last naturally until the end supports are eroded away.

Do you remember the small rock shelter we observed at Stop 2 near Hawks' Cave at Ferne Clyffe State Park? Given the right conditions and enough time, do you think the jointed rock shelter at Ferne Clyffe might develop into a natural arch?

A large rock shelter has been formed near the base of the cliff below the road turn-around near the lower parking area for Bell Smith Springs. Stone stairs have been constructed down to the base of the cliff from the parking area. The rock shelter is at the bottom of the steps.

Springs have formed where surface water has percolated down through the porous sandstone until it has met with the impermeable shales of the unamed interval below the Pounds Sandstone. The water then has moved laterally until it has intersected the valley wall, appearing as a series of springs of varying flow rates. Water seeping along the interface between the sandstone and the underlying shale has kept the shale wet and slippery. Thus, as intersecting joints in the sandstone slowly become enlarged, more water can be admitted to the confined area to mechanically erode the shale and help to produce rounded slopes under the edge of the large sandstone blocks. Eventually, freeze-thaw expansion and contraction, combined with slow gravity sliding, causes some of these large blocks to become detached or fall over. You can see a number of examples of these processes in this area.

STOP 7: Millstone Bluff (SE, NW, NW, Sec.20, T12S, R5E, 3 rd P.M., Glendale 7.5-minute Quadrangle, Pope County).

Located at the base of Millstone Bluff is the abandoned Mississippian Kinkaid Limestone quarry (fig. 17).

CAUTION: The rocks in the quarry face and the overlying slopes within the abandoned quarry may be unstable. Remember to look up BEFORE you pull some specimen from the face. Make sure no one is standing above you at any time. Do NOT get close to the quarry edges if you are working up the slopes, because the edges can give away suddenly, even a foot or two back from the lip.

The rocks exposed in this abandoned quarry are the Mississippian age Kinkaid Limestone. These rocks represent a portion of the same sequence which we observed at Stop 4. There is a thin, persistent shale about 6 to 7 feet above the main quarry floor. Everything above this shale parting in the quarry is part of the Cave Hill Shale Member of the Kincaid Limestone.

The top of the quarry face is nearly 37 feet above the shale parting. The contact between the Kinkaid Limestone and the overlying, lowermost

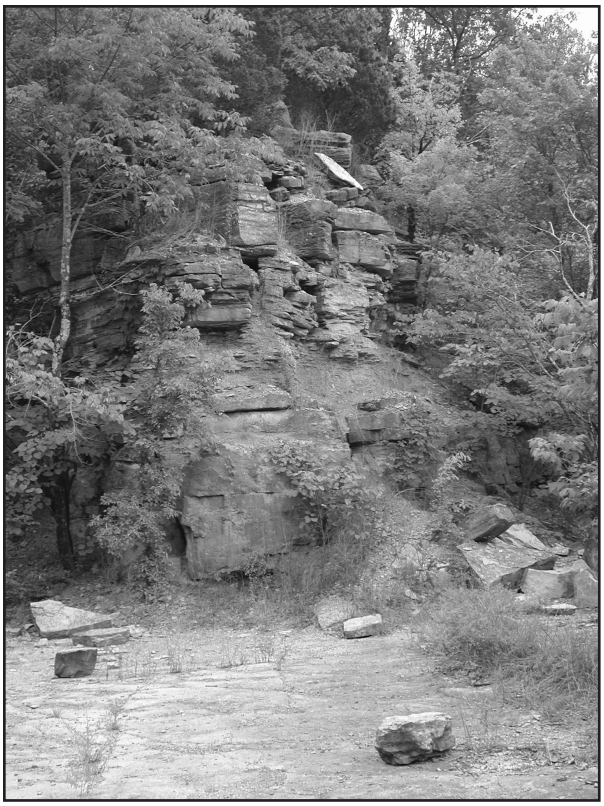


Figure 17 Abandoned quarry in the Mississippian age Kinkaid Limestone at the base of Millstone Bluff at Stop 7 (photo by Wayne T. Frankie).

Pennsylvanian strata is perhaps 10 feet farther up the slope, but is covered by slump. Above that position are float pieces of Pennsylvanian sandstone. The topmost units in the Kinkaid, a greenish gray shale and the green and red variegated shale, appear to be completely covered by slumping above the quarry face.

In studying this exposure, you will gain some understanding of the problems encountered in working out the geology of this part of Illinois. The Cave Hill Shale Member is generally poorly exposed in this area. Although several of the limestones appear to be thick-bedded or massive, they are argillaceous (clayey) and, thus, relatively weak and weather easily. Some of these units are fossiliferous, but don't risk life and limb to get some fossils. Worse yet, don't risk your neighbors'.

Millstone Bluff

The bluff is located on Illinois Route 147 northeast of the little village of Robbs. A scenic walkway and the wooden stairways make hiking to the top much easier than the trails used by the Native Americans and our forefathers. Information tablets are filled with historical facts and are strategically placed along the winding trail atop the bluff.

The following information on the historical significance of the Millstone Bluff National Register site was modified from information supplied by the USDA Forest Service.

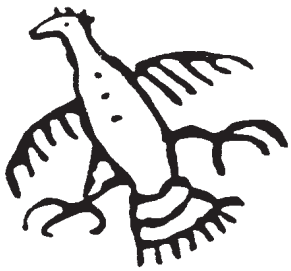
Millstone Bluff is the site of an undisturbed prehistoric Mississippian village, a stonebox cemetery, and rock art. The bluff itself is a unique topographical feature rising 320 feet above the surrounding comparatively flat terrain. It appears as an "island" amid the hills. Bay Creek, a major tributary of the Ohio River, is located west and north of the bluff. It was so named because early settlers in the area carved milling stones along the base of the northwestern edge of the bluff. These hand-carved millstones were used to mill local farmer's grains into flour.

Millstone Bluff is surrounded by a massive sandstone escarpment. Large sandstone boulders lying at irregular angles are scattered along the steep slopes.

Although the human occupation at Millstone Bluff extends from A.D. 500 to A.D. 1500, the majority of the artifacts recovered from the site are Mississippian (A.D. 900 to 1500). The village consists of approximately 24 house depressions loosely clustered around a central plaza. These are the remains of rectangular, semi-subterranean mud and stick, thatched houses. When one of the rectangular houses is abandoned or burned, the square basement-like hole fills in, forming a rounded basin-like depression. There were probably two to six individuals per household living at Millstone Bluff, including parents, children, and perhaps grandparents.

The village cemetery is located nearby. It contains approximately 20 coffin-like stone boxes. The prehistoric people of Millstone Bluff buried many of their dead in rectangular graves lined with large, thin limestone slabs to form a box. Past looting and vandalism have destroyed the great majority of the graves. Prehistoric burials are primary targets for "pothunters" in the eastern United States because of the likelihood of recovering valuable stone tools and whole pottery vessels within the grave. Numerous depressions resulting from looting and vandalism activities are visible.

The rock art or petroglyphs present at Millstone Bluff were almost certainly carved by Mississippian Indians. The figures depicted are similar to other Mississippian motifs found on pottery, carved stone figurines, and engraved copper plates. The figures are actually "pecked" into the stone, and not "carved"—they are formed by the repeated battering or hammering of a small "hammerstone" onto the flat rock surface. It is unknown exactly what the figures represent, but they are similar to mythic creatures found in Cherokee legends and stories. For example, the spider depicts the water strider that brought fire from an island to the Cherokee on the mainland when other beasts such as the bear and raven could not for fear of being burned.



Millstone Bluff is a very special place. Nowhere else in southern Illinois have the former Native American occupants left such diverse evidence of southern Illinois' rich prehistoric past. Please help us protect our nation's prehistoric past and fragile archaeological resources by walking softly in the footsteps of the Mississippian villagers. Remember—these resources belong to all of us. Please help us protect our common heritage

For more information about the Shawnee National Forest, contact the USDA Forest Service by writing or calling the following offices; USDA Forest Service, Shawnee National Forest, 50 Highway 145 South, Harrisburg, IL 62946 (618-253-1070 or USDA Forest Service, Shawnee National Forest, P.O. Box 37, Highway 45 North, Vienna, IL 62995 (618-658-2111).

Alternative STOP 8: Railroad cut at Robbs (SW, NW, SW, SE, Sec. 19, T12S, R5E, 3rd P.M., Glendale 7.5-minute Quadrangle, Pope County)

At this stop you can observe a chevron fold along the west side of the Illinois Central Gulf Railroad cut at Robbs. This stop does not lend itself to a large group.

From Millstone Bluff, the Robbs railroad cut is 0.5 miles west of the entrance road. To observe the chevron fold, park along Bull Pen Road, which is located immediately east of the railroad overpass. The railroad cut is west of Bull Pen Road. The folded rocks are approximately 0.35 miles south of Illinois Route 147.

CAUTION: Do NOT get too close to the edge of the railroad cut. It is very steep and unstable. Do NOT attempt to walk in from the ends of the cut. It is extremely dangerous and on PRIVATE PROPERTY!

Bedrock exposed along the railroad cut belongs to the Mississippian Clore Formation, which is composed of two members in outcrop here: the upper Ford Station Limestone Member and the Tygett Sandstone Member that occurs near the middle of the Clore. Nearly 100 feet of the Clore is exposed along this railroad cut. The Ford Station Limestone is a sequence of alternating shale, sandstone, and limestone units of varying thicknesses and character, some of which are fairly fossiliferous. The Tygett Sandstone Member occurs near the middle of the formation. This fine-grained sandstone contains abundant plant debris near the top, including *Stigmaria* roots and rootlets in place.

The bedrock structure here is of particular interest, especially because this is one of the relatively few

places in Illinois where folded and/or faulted strata can be easily seen. The view of the west side of the railroad cut shows interbedded sandstones and shales of the Mississippian Clore Formation sharply folded upward into a small inverted v- shape. The structure is a sharp crested asymmetrical anticline. The axis of the fold is N60^0 W. The fold is approximately 125 feet wide and shows a structural height of 15 to 20 feet at the crest, being nearly perpendicular to the tracks. From the vicinity of the Illinois Route 147 overpass, approximately 0.35 miles to the north, bedrock strata rise gradually southward through the railroad cut, finally steepening rapidly to 19 degrees near the crest of the fold. The rock layers along the south limb of the fold axis have steep dips of 29 degrees. The steepening is much more rapid on the south than on the north side of the crest.

Associated with the chevron fold are several small thrust faults and flexures. Thrust faults near the center of the structure on both sides of the track follow bedding planes in the shale and then steepen at the crest and shear across bedding surfaces. North of the crest on the west side, there appears to be a steep, north-dipping reverse fault that has offset the sandstone 4 or 5 feet. The sandstone is shattered in that location, and the exposure is not clean. Clearly, this structure has resulted from horizontal compressive forces that acted within the Earth after the sediments had become lithified.

Alternative STOP 9: Mississippian Menard Limestone, Interstate 24 (NW NE SW Sec. 3, T135, T3E, 3rd P.M., Johnson County, Bloomfield 7.5-minute Quadrangle).

This stop is located east of Vienna along the Interstate 24 westbound entrance ramp. Exposure of Mississippian Menard Limestone along the east and northeast sides of the Interstate 24 access ramp. This locality is easily accessible and is a good fossil collecting location.

The roadcut on the Interstate 24 ramp exposes an upper Chesterian unit called the Menard Limestone (fig. 2). The rocks exposed here are stratigraphically lower than the rocks exposed at Stop 4.

Interpretation of the Mississippian Environment

About 320 million years ago, a shallow ocean covered this location and much of Illinois, Indiana, and Kentucky. The types of animals that lived here—corals, bryozoans, crinoids, and blastoids—tell us that the sea was warm and tropical. Attached to the sea floor were crinoids, blastoids, and lattice-like fenestrate bryozoans. During this period, the Mississippian, trilobites were smaller than they were during earlier geologic times and on their way to extinction during the Permian Period.

Brachiopods lived in clusters. Bivalves (clams) also were present. Large shell-crushing sharks occasionally tore up bits of the sea floor and filtered out the shelled animals from the limy mud. These sharks smashed the shelled creatures with their pavement-like teeth and digested the delicate parts of these organisms.

The ocean became cloudy at times either from storms churning the sea floor or from clay being washed in from deltas emptying into the sea. The fine clay material settled out and is now preserved as the shaly intervals commonly seen in the Menard today. When the sea was less cloudy, relatively clean limestone formed. Some limestone strata consist of animal graveyards where countless skeletons of ancient invertebrates were transported and dumped. These types of limestones are called packstones or grainstones, depending on the amount of fine mud mixed in with the shell fragments.

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GLOSSARY

The following definitions are adapted in total or in part from several sources. The principal source is R.L. Bates and J.A Jackson, eds., 1987, *Glossary of Geology*, 3rd ed.: Alexandria, Virginia, American Geological Institute, 788 p.

ablation Separation and removal of rock material and formation of deposits, especially by wind action or the washing away of loose and soluble materials.

accretion The gradual or imperceptible increase or extension of land by natural forces acting over a long period of time.

age An interval of geologic time; a division of an epoch.

aggraded Built up by deposition.

alluviated valley One that has been at least partially filled with sand, silt, and mud by flowing water.

alluvium A general term for clay, silt, sand, gravel, or similar unconsolidated sorted or semisorted sediment deposited during comparatively recent time by a stream or other body of running water.

angular unconformity The name of the contact when the beds below the unconformity are tilted and eroded prior to deposition of overlying beds.

anticline A convex-upward rock fold in which strata have been bent into an arch; the strata on either side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.

aquifer A geologic formation that is water-bearing and that transmits water from one point to another.

arenite A relatively clean quartz sandstone that is well sorted and contains less than 10% argillaceous material.

argillaceous Said of rock or sediment that contains, or is composed of, clay-sized particles or clay minerals.

basement complex The suite of mostly crystalline igneous and/or metamorphic rocks that generally underlies the sedimentary rock sequence.

basin A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; the term also denotes an area of relatively deep water adjacent to shallow-water shelf areas.

bed A naturally occurring layer of earth material of relatively greater horizontal than vertical extent that is characterized by physical properties different from those of overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a stream channel.

bedrock The solid rock (sedimentary, igneous, or metamorphic) that underlies the unconsolidated (non-indurated) surface materials (for example, soil, sand, gravel, glacial till).

bedrock valley A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

biota All living organisms of an area; plants and animals considered together.

bioturbation Disruption, especially churning and stirring, of sediments by living organisms.

calcarenite Describes a limestone composed of more or less worn fragments of shells or pieces of older limestone. The particles are generally sand-sized.

calcareous Said of a rock containing some calcium carbonate ($CaCO_3$), but composed mostly of something else (synonym: limey).

calcite A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

cap rock The top layer of rock.

chert Silicon dioxide (SiO_2); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint, but lighter in color.

clastic Said of rocks composed of particles of other rocks or minerals, including broken organic hard parts as well as rock substances of any sort, transported and deposited by wind, water, ice, or gravity.

claypan (soil) A heavy, dense subsurface soil layer that owes its hardness and relative imperviousness to higher clay content than that of the overlying material.

columnar section A graphic representation, in the form of one or more vertical columns, of the vertical succession and stratigraphic relations of rock units in a region.

conformable Said of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

cuesta A ridge with a gentle slope on one side and a steep slope on the other.

delta A low, nearly flat, alluvial land form deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain extending beyond the general trend of a coastline.

detritus Loose rock and mineral material produced by mechanical disintegration and removed from its place of origin by wind, water, gravity, or ice; also, fine particles of organic matter, such as plant debris.

disconformity An unconformity marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable time interval of nondeposition.

distributary Irregular, divergent stream flowing away from the main stream and not returning to it, as in a delta.

dolomite A mineral, calcium-magnesium carbonate ($Ca,Mg(CO_3)_2$); also the name applied to sedimentary rocks composed largely of the mineral. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; and effervesces feebly in cold dilute hydrochloric acid.

dome A general term for any smoothly rounded landform or rock mass that roughly resembles the dome of a building.

drift All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

earthquake Ground displacement associated with the sudden release of slowly accumulated stress in the lithosphere.

end moraine A ridge or series of ridges formed by accumulations of drift built up along the outer margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

epoch An interval of geologic time; a division of a period (for example, Pleistocene Epoch).

era The unit of geologic time that is next in magnitude beneath an eon; it consists of two or more periods (for example, Paleozoic Era).

erratic A rock fragment carried by glacial ice and deposited far from its point of origin.

escarpment A long, more or less continuous cliff or steep slope facing in one general direction; it generally marks the outcrop of a resistant layer of rocks or the exposed plane of a fault that has moved recently.

evaporite A nonclastic sedimentary rock composed primarily of minerals produced from a saline solution as a result of extensive or total evaporation of the solvent (for example, gypsum, anhydrite, rock salt, primary dolomite, and various nitrates and borates).

fault A fracture surface or zone of fractures in earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on opposite sides relative to each other.

flaggy Said of rock that tends to split into layers of suitable thickness for use as flagstone.

floodplain The surface or strip of relatively smooth land adjacent to a stream channel produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

fluvial Of or pertaining to a river or rivers.

formation The basic rock unit, one distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types. Formations have formal names, such as Joliet Formation or St. Louis Limestone (formation), generally derived from the geographic localities where the unit was first recognized and described.

fossil Any remains or traces of a once-living plant or animal preserved in rocks (arbitrarily excludes recent remains); any evidence of ancient life. Also used to refer to any object that existed in the geologic past and for which evidence remains (for example, a fossil waterfall)

fragipan A dense subsurface layer of soil whose hardness and relatively slow permeability to water are chiefly due to extreme compactness rather than to high clay content (as in claypan) or cementation (as in hardpan).

friable Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft and poorly cemented sandstone.

geology The study of the planet Earth that is concerned with its origin, composition, and form, its evolution and history, and the processes that acted (and act) upon the Earth to control its historic and present forms.

geophysics Study of the Earth with quantitative physical methods. Application of the principles of physics to the study of the Earth, especially its interior.

glaciation A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

glacier A large, slow-moving mass of ice formed on land by the compaction and recrystallization of snow.

graben An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides.

gradient A part of a surface feature of the Earth that slopes upward or downward; the angle of slope, as of a stream channel or of a land surface, generally expressed by a ratio of height versus distance, a percentage or an angular measure from the horizontal.

gypsum A widely distributed mineral consisting of hydrous calcium sulfate ($CaSO_4 \cdot 2H_2O$). Gypsum is soft (hardness of 2 on the Mohs scale); white or colorless when pure but commonly has tints of gray, red, yellow, blue, or brown. Gypsum is used as a retarder in portland cement and in making plaster of Paris.

hiatus A gap in the sedimentary record.

horst An elongate, relatively uplifted crustal unit or block that is bounded by faults on its long sides.

igneous Said of a rock or mineral that solidified from molten or partly molten material (that is, from magma).

indurated Said of compact rock or soil hardened by the action of pressure, cementation, and, especially, heat.

joint A fracture or crack in rocks along which there has been no movement of the opposing sides (*see also* fault).

karst Collective term for the land forms and subterranean features found in areas with relatively thin soils underlain by limestone or other soluble rocks; characterized by many sinkholes separated by steep ridges or irregular hills. Tunnels and caves formed by dissolution of the bedrock by groundwater honeycomb the subsurface. Named for the region around Karst in the Dinaric Alps of Croatia where such features were first recognized and described.

lacustrine Produced by or belonging to a lake.

lava Molten, fluid rock that is extruded onto the surface of the Earth through a volcano or fissure. Also the solid rock formed when the lava has cooled.

limestone A sedimentary rock consisting primarily of calcium carbonate (the mineral calcite). Limestone is generally formed by accumulation, mostly in place or with only short transport, of the shells of marine animals, but it may also form by direct chemical precipitation from solution in hot springs or caves and, in some instances, in the ocean.

lithify To change to stone, or to petrify; especially to consolidate from a loose sediment to a solid rock.

lithology The description of rocks on the basis of their color, structure, mineral composition, and grain size; the physical character of a rock.

local relief The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.

loess A homogeneous, unstratified accumulation of silt-sized material deposited by the wind.

magma Naturally occurring molten rock material generated within Earth and capable of intrusion into surrounding rocks or extrusion onto the Earth's surface. When extruded on the surface it is called lava. The material from which igneous rocks form through cooling, crystallization, and related processes.

meander One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.

meander scars Crescent-shaped swales and gentle ridges along a river's floodplain that mark the positions of abandoned parts of a meandering river's channel. They are generally filled in with sediments and vegetation and are most easily seen in aerial photographs.

metamorphic rock Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (for example, gneisses, schists, marbles, and quartzites)

mineral A naturally formed chemical element or compound having a definite chemical composition, an ordered internal arrangement of its atoms, and characteristic crystal form and physical properties.

moraine A mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited in a variety of topographic land forms that are independent of control by the surface on which the drift lies (*see also* end moraine).

morphology The scientific study of form and of the structures and development that influence form; term used in most sciences.

nonconformity An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.

nonlithified Said of unconsolidated materials.

normal fault A fault in which the hanging wall appears to have moved downward relative to the footwall.

outwash Stratified glacially derived sediment (clay, silt, sand, and gravel) deposited by meltwater streams in channels, deltas, outwash plains, glacial lakes, and on floodplains.

outwash plain The surface of a broad body of outwash formed in front of a glacier.

overburden The upper part of a sedimentary deposit, compressing and consolidating the material below.

perched groundwater Unconfined groundwater separated from an underlying body of groundwater by an unsaturated zone.

perched water table The water table of a body of perched groundwater.

period An interval of geologic time; a division of an era (for example, Cambrian, Jurassic, and Tertiary).

physiographic province (or division) (a) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history. (b) A region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

physiography The study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes.

point bar A low arcuate ridge of sand and gravel developed on the inside of a stream meander by accumulation of sediment as the stream channel migrates toward the outer bank.

polycheate worms A class of annelid (segmented marine worms) common to sea coasts where some lived in U-shaped tubes in beach sands; its chitinous jaws may be preserved in many rock systems, from Precambrian to Recent.

relief (a) A term used loosely for the actual physical shape, configuration, or general uneveness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given regional extent. Formed in places where the forces of plate tectonics are beginning to split a continent (for example, east African rift valley).

rift (a) A narrow cleft, fissure, or other opening in rock made by cracking or splitting. (b) A long, narrow continental trough that is bounded by normal faults—a graben of regional extent.

riprap A layer of large, durable fragments of broken rock, specially selected and graded, thrown together irregularly or fitted together to prevent erosion by waves or currents and to preserve the shape of a surface, slope, or underlying structure.

sediment Solid fragmental matter, either inorganic or organic, that originates from weathering of rocks and is transported and deposited by air, water, or ice or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms. When deposited, sediment generally forms layers of loose, unconsolidated material (for example, sand, gravel, silt, mud, till, loess, and alluvium).

sedimentary rock A rock resulting from the consolidation of loose sediment that has accumulated in layers (for example, sandstone, siltstone, mudstone, and limestone).

shoaling Said of an ocean or lake bottom that becomes progressively shallower as a shoreline is approached. The shoaling of the ocean bottom causes waves to rise in height and break as they approach the shore.

silt A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 4 to 62 microns; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye.

sinkhole Any closed depression in the land surface formed as a result of the collapse of the underlying soil or bedrock into a cavity. Sinkholes are common in areas where bedrock is near the surface and susceptible to dissolution by infiltrating surface water. Sinkhole is synonymous with "doline," a term used extensively in Europe. The essential component of a hydrologically active sinkhole is a drain that allows any water that flows into the sinkhole to flow out the bottom into an underground conduit.

slip-off slope Long, low, gentle slope on the inside of a stream meander. The slope on which the sand that forms point bars is deposited.

stage, substage Geologic time-rock units; the strata formed during an age or subage, respectively. Generally applied to glacial episodes (for example, Woodfordian Substage of the Wisconsinan Stage).

strata Layers of sedimentary rock, visually separable from other layers above and below; beds.

stratigraphic unit A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

stratigraphy The study, definition, and description of major and minor natural divisions of rocks, particularly the study of their form, arrangement, geographic distribution, chronologic succession, naming or classification, correlation, and mutual relationships of rock strata.

stratum A tabular or sheet-like mass, or a single, distinct layer of material of any thickness, separable from other layers above and below by a discrete change in character of the material, a sharp physical break, or both. The term is generally applied to sedimentary rocks but could be applied to any tabular body of rock (*see also* bed).

syncline A convex-downward fold in which the strata have been bent to form a trough; the strata on either side of the core of the trough are inclined in opposite directions toward the axis of the fold; the core area of the fold contains the youngest rocks (*see also* anticline).

system A fundamental geologic rock unit of worldwide significance; the strata of a system are those deposited during a period of geologic time (for example, rocks formed during the Pennsylvanian Period are included in the Pennsylvanian System).

tectonic Pertaining to the global forces that cause folding and faulting of the Earth's crust; also used to classify or describe features or structures formed by the action of those forces.

tectonics The branch of geology dealing with the broad architecture of the upper (outer) part of Earth; that is, the major structural or deformational features, their origins, historical evolution, and relations to one another. It is similar to structural geology, but generally deals with larger features such as whole mountain ranges or continents.

terrace A long, narrow, relatively level or gently inclined surface bounded on one side by a steeper descending slope and along the other by a steeper ascending slope; a large bench or steplike ledge breaking the continuity of a slope. A terrace commonly occurs along the margin and above the level of a body of water, marking a former water level.

till Nonlithified, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogenous mixture of different sizes and kinds of rock fragments.

till plain The undulating surface of low relief in an area underlain by ground moraine.

topography The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

unconformable Said of strata that do not succeed the underlying rocks in immediate order of age or in parallel position. A general term applied to any strata deposited directly upon older rocks after an interruption in sedimentation, with or without any deformation and/or erosion of the older rocks.

unconformity A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic successsion.

valley train The accumulation of outwash deposited by rivers in their valleys downstream from a glacier.

water table The point in a well or opening in the Earth where groundwater begins. It generally marks the top of the zone where the pores in the surrounding rocks are fully saturated with water.

weathering The group of processes, both chemical and physical, whereby rocks exposed to the weather change in character and decay and finally crumble into soil.

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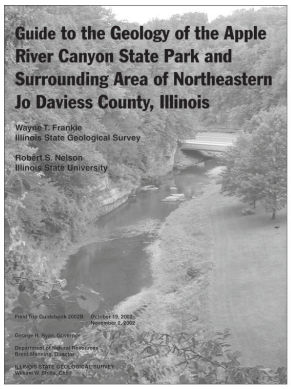

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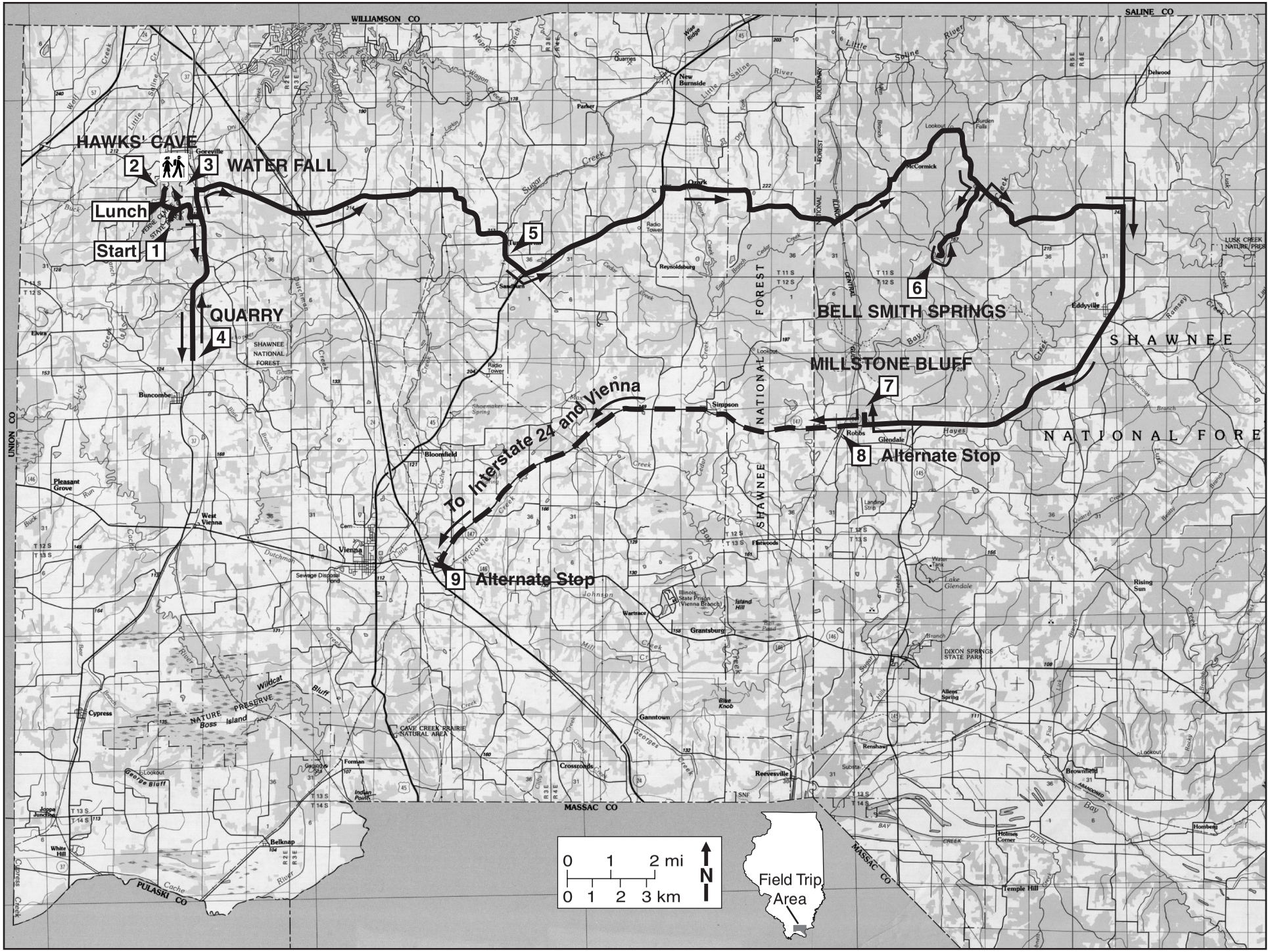
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